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Subject: Environmental Impacts for the Pesticide Active Ingredient Production NESHAP
EPA Contract No. 68D60012; Task Order No. 0004
ESD Project No. 93/59; MRI Project No. 4800-04

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I. Introduction

The purpose of this memorandum is to present the environmental impacts and the approach used to estimate the impacts for regulatory alternatives that were developed for the national emissions standards for hazardous air pollutants (NESHAP) for pesticide active ingredient (PAI) production. The environmental impacts that were estimated include (1) primary air impacts; (2) secondary impacts, including air, water, and solid waste; and (3) fuel and electricity impacts. The impacts are presented for each of the five emission source types or "planks" (i.e., process vents, equipment leaks, storage tanks, wastewater systems, and bag dumps and product dryers).

II. Basis for Impacts Analysis

Regulatory alternatives (including the maximum achievable control technology [MACT] floor) for existing sources are described in detail in the MACT floor and regulatory alternatives memorandum.[1] In summary, the MACT floor was developed for all five emission source types; one additional regulatory alternative was developed for storage tanks, wastewater systems, and equipment leaks; and two additional regulatory alternatives were developed for process vents. Impacts were estimated for the MACT floor and all regulatory alternatives. The emissions and the model plants for each plank are described in the Data Summary, Model Plant, and Baseline Emissions memoranda.[2,3,4]

To comply with the regulatory alternatives for gaseous organic HAP emissions from process vents, this analysis assumes that PAI facilities would use thermal incinerators to control organic HAP emissions from dilute streams; control of concentrated streams was assumed to be achieved with refrigerated condensers. Water scrubbers (gas absorbers) were assumed to be used to control hydrochloric acid (HCl) emissions from process vents. Compliance with the regulatory alternatives for storage tanks was assumed to be achieved with the installation of internal floating roofs (IFR) for tanks with capacities greater than or equal to 76 m^3 (20,000 gallons) and condensers for tanks with smaller capacities. Compliance with regulatory alternatives for wastewater systems was assumed to be achieved with steam strippers. Compliance with the regulatory alternatives for equipment leaks was assumed to be achieved by implementing a leak detection and repair (LDAR) program. Fabric filters were assumed to be used to control particulate matter from bag dumps and product dryers. Emissions from bag dumps and product dryers are already controlled to the level required by the MACT floor; there are no environmental impacts associated with implementation of the requirement for bag dumps and product dryers.

III. Primary Air Impacts

Primary air impacts consist of the reduction in HAP emissions from the baseline level that is directly attributable to the regulatory alternative. The primary air impacts for each emission source type under each regulatory alternative are shown in Table 1.

TABLE 1. SUMMARY OF PRIMARY AIR IMPACTS FOR MACT FLOOR AND REGULATORY ALTERNATIVES

	Emission reduction from baseline		
Emission source type	MACT floor, Mg/yr	Regulatory alternative 1, Mg/yr	Regulatory alternative 2, Mg/yr
Process vents - Organic HAP's - HCl	 616 458	 714 458	 966 567
Equipment leaks	0	3,020	N/A
Storage tanks	10.5	20.0	N/A
Wastewater systems	0	934	N/A
Bag dumps and product dryers	0	N/A	N/A

A. Process Vents

Primary air impacts for process vents at the MACT floor are 616 Mg/yr organic HAP emissions and 458 Mg/yr for HCl emissions. Primary impacts for organic HAP and HCl emissions under regulatory alternative 1 are 714 Mg/yr and 458 Mg/yr, respectively. Under regulatory alternative 2, the primary impacts are 966 Mg/yr for organic HAP emissions and 567 Mg/yr for

HCl emissions. Impacts for each process were estimated based on the difference between the baseline control level for the process and the control level required by the MACT floor or the regulatory alternative. The impacts for each process under each regulatory alternative are shown in Attachment 1.

B. <u>Equipment Leaks</u>

Primary air impacts for equipment leaks at the MACT floor are 0 Mg/yr because the MACT floor is no control. Primary impacts under regulatory alternative 1 are 3,020 Mg/yr. The EPA protocol document for estimating equipment leak emissions presents control effectiveness values for components that are controlled using the LDAR program in the HON.[5] These values were applied to the baseline emissions for 14 individual processes where the component counts were known and to the batch and continuous model component counts for other processes. Details of this analysis are presented in Attachment 2.

C. <u>Storage Tanks</u>

The primary air impacts for storage tanks under the MACT floor are 10.5 Mg/yr for HAP emissions. Under regulatory alternative 1, HAP emissions would be reduced by 20.0 Mg/yr. The control levels and associated applicability cutoffs for the floor and regulatory alternative were applied to the 82 surveyed tanks and the 238 modelled tanks to estimate the HAP emission reduction achieved. The emissions for each of the tanks are provided in Attachment 3.

D. <u>Wastewater Systems</u>

The primary air impacts for wastewater at the MACT floor are 0 Mg/yr (the floor is no control). Primary impacts under regulatory alternative 1 are 934 Mg/yr. These impacts were calculated for the 30 wastewater streams nationwide with process wastewater streams that meet the applicability cutoffs for the regulatory alternative.[1,3] Details of this analysis are shown in Attachment 4.

E. <u>Bag Dumps and Product Dryers</u>

Primary air impacts for the bag dumps and product dryers at the MACT floor are 0 Mg/yr; emissions from this source type are already controlled to the MACT floor level.

IV. <u>Secondary Environmental Impacts</u>

Secondary environmental impacts consist of any adverse or beneficial environmental impacts other than the primary impacts described in Section III. The secondary impacts are indirect or induced air, water, or solid waste impacts that result from the operation of the control system that controls HAP emissions. Use of most of the control systems described in Section II of this memorandum will cause secondary air impacts; secondary water and solid waste impacts, however, are expected to be minimal. The secondary environmental impacts for both the surveyed plants and the modelled plants were based on the use of models to represent actual emission source types (i.e., site-specific impacts were not estimated for the surveyed plants). The secondary air, water, and solid waste impacts are discussed in the sections below.

A. Secondary Air Impacts

Secondary air impacts consist of: (1) generation of emissions as the byproducts of fuel combustion needed to operate control devices, and (2) reductions in emissions of VOC compounds. These secondary air impacts are discussed below.

Fuel combustion is necessary to maintain operating temperatures in incinerators, to produce steam for steam strippers, and to generate electricity for operating fans, pumps, and refrigeration units. Byproducts of fuel combustion include emissions of carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and PM less than 10 microns in diameter (PM_{10}).

Steam was assumed to be generated in small, natural gas-fired industrial boilers. Incinerator control devices also use natural gas as the auxiliary fuel. The estimated natural gas consumption rates are described in Section V. Emissions from combustion in both the boilers and incinerators were estimated using AP-42 emission factors for small industrial boilers.[6]

Electricity was assumed to be generated at coal-fired utility plants built since 1978. The estimated electricity requirements, and the fuel energy needed to generate this electricity, are described in Section V. Utility plants built since 1978 are subject to the new source performance standards (NSPS) in subpart Da of 40 CFR part 60.[7] These NSPS were used to estimate the PM_{10} and SO_2 emissions from coal combustion. The NO_x emissions were estimated using the AP-42 emission factor because the emission factor is lower than the level required by the NSPS.[8] The CO emissions were estimated using the AP-42 emission factor because CO emissions are not covered by the NSPS.[8] The sulfur content of the coal was assumed to be 1.8 percent.

A summary of the estimated secondary air impacts that are generated for each of the five emission source types is presented in Table 2. Secondary air impacts are generated from operation of thermal incinerators, condensers, and scrubbers for process vents, condensers for storage tanks, and steam strippers for wastewater streams. There is no generation of secondary air impacts associated with the use of floating roofs to control emissions from storage tanks or with the implementation of an

LDAR program to control equipment leaks. In addition, no secondary air impacts result from control of bag dumps and product dryers because the MACT floor control level is equivalent to baseline control. The secondary air impact calculations for each type of emission source is provided in Attachment 5.

In addition to the generation of emissions from fuel combustion for the operation of control devices, secondary air impacts also include the reduction of VOC emissions. This reduction in VOC emissions includes reduction of: (1) non-HAP VOC emissions and (2) HAP compounds that are also VOC compounds. The VOC compounds are precursors to ozone. The reduction of VOC achieved by the MACT floor and regulatory alternatives can not be quantified.

B. Secondary Water Impacts

Secondary water impacts consist of wastewater blowdown from water scrubbers used to control HCl emissions from process vents. Wastewater from HCl scrubbers is estimated to increase by 10.8 million liters per year (2.86 million gallons per year). The amount of wastewater generated from each model scrubber is estimated in the design and cost algorithms for scrubbers used with each model process; these algorithms are included in the cost impacts memorandum.[9] A summary of the wastewater impacts is provided in Table 3.

TABLE 3. WASTEWATER IMPACTS FROM HCL SCRUBBERS

Model	Increase in wastewater flowrate, gal/yr/scrubber	Number of models	Nationwide increase in wastewater flowrate, gal/yr
2d	222,789	5	1,113,947
2c	133,632	2	267,263
4d	307,158	4	1,228,631
4c	249,895	1	249,895
Total			2,860,000

To simplify the analysis, one approach was used to estimate the amount of increased scrubber blowdown for the MACT floor and both regulatory alternatives. This approach assumes that all of the HCl in the gas stream is neutralized and the maximum acceptable dissolved solids concentration in the circulatory water is 10 weight percent.[10] As a result, the estimated

TABLE 2. SUMMARY OF SECONDARY AIR IMPACTS

Emisson source type	Units	MACT floor				Regulatory alternative 1				Regulatory alternative 2			
		CO^a	$NO_x{}^b$	$SO_2{}^c$	$PM_{10}{}^d$	CO^a	$NO_x{}^b$	$SO_2{}^c$	$PM_{10}{}^d$	CO^a	$NO_x{}^b$	$SO_2{}^c$	$PM_{10}{}^d$
Process vents	Mg/yr	100	359	228	17.5	107	378	274	18.6	111	388	298	19.3
Equipment leaks	Mg/yr	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
Storage tanks	kg/yr	0.16	0.43	1.89	0.03	0.16	0.43	1.89	0.03	N/A	N/A	N/A	N/A
Wastewater systems	Mg/yr	0	0	0	0	2.85	11.3	0.85	0.012	N/A	N/A	N/A	N/A
Bag dumps and product dryers	Mg/yr	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[a]The CO emissions were estimated using AP-42 emission factors of 5 lb CO/ton of coal and 35 lb $CO/10^6$ ft^3 of natural gas.
[b]The NO_x emissions were estimated using AP-42 emission factors of 13.7 lb NO_x/ton of coal and 140 lb $NO_x/10^6$ ft^3 of natural gas.
[c]The SO_2 emissions were estimated using the NSPS for coal-fired utility boilers of 1.2 lb $SO_2/10^6$ Btu and the AP-42 emission factor of 0.6 lb $SO_2/10^6$ ft^3 of natural gas.
[d]The PM_{10} emissions were estimated using the NSPS for coal-fired utility boilers of 0.03 lb/10^6 Btu and the AP-42 emission factor of 6.2 lb $PM_{10}/10^6$ ft^3 of natural gas.

increase in scrubber blowdown is the same under the MACT floor and both regulatory alternatives. This approach may overestimate the increase in wastewater under the MACT floor and Regulatory Alternative 1 by up to 30 percent because the baseline control level is 80 percent, and the HCl control level under the MACT floor and Regulatory Alternative 1 is 94 percent, not 100 percent. However, the difference is likely to be less than 30 percent because it is expected that most controls used to achieve the required 94 percent reduction for the floor and Regulatory Alternative 1 will actually have much higher control efficiencies. Similarly, the increase in scrubber blowdown under Regulatory Alternative 2 may be overestimated by as much as 5 percent because the HCl control efficiency under regulatory alternative 2 is 99 percent.

The volume of wastewater generated would also increase at plants that choose to use a water scrubber to control certain water soluble organic HAP's; this volume was not estimated because the use of water scrubbers is expected to be uncommon.

C. Secondary Solid Waste Impacts

Solid waste impacts are expected to be minimal. Captured PM HAP emissions from bag dumps and product dryers are expected to be either raw material or product that would be returned to the process. At some plants, the overheads from a steam stripper (i.e., the mixture of steam and volatilized organic compounds) may be a waste that needs to be disposed of. Other plants, however, may be able to condense the overheads and return the condensed material to the process as either raw material or fuel. Thus analysis assumes the waste costs at some plants are balanced by the savings at other plants.

V. Energy Impacts

Energy impacts consist of the fuel usage and electricity needed to operate control devices that are used to comply with the regulatory alternatives. The estimated electricity and fuel impacts for each of the five emission source types are presented in Table 4. In each case, the impacts are based on the total amount of electricity or fuel needed to operate the control devices; electricity and fuel needs for existing controls are assumed to be negligible. The energy impacts, like the secondary impacts, were based on the use of models to represent both the surveyed plants and the modelled plants. The electricity and fuel impacts are estimated in the cost algorithms for control devices developed for each of the models; these algorithms are included in the Cost Impacts memorandum.[9] The tables in Attachment 5 provide the estimated electricity and fuel impacts for each of the models and the nationwide impacts. The electricity and fuel impacts are discussed in the sections below.

TABLE 4. SUMMARY OF ENERGY IMPACTS

Emission source type	Increase in electricity consumption, kwh/yr	Increase in steam consumption, lb/yr	Increase in fuel energy, Btu/yr			
			To generate electricity	Auxiliary fuel for incinerators	To produce steam	Total
Process vents						
MACT Floor	42.7×10^6	0	$4,160 \times 10^8$	$42,000 \times 10^8$	0	$46,100 \times 10^8$
Regulatory Alternative 1	51.4×10^6	0	$5,010 \times 10^8$	$42,000 \times 10^8$	0	$47,000 \times 10^8$
Regulatory Alternative 2	56.0×10^6	0	$5,460 \times 10^8$	$42,000 \times 10^8$	0	$47,400 \times 10^8$
Equipment leaks						
MACT Floor	0	0	0	0	0	0
Regulatory Alternative 1	0	0	0	0	0	0
Storage tanks						
MACT Floor	198	0	0.0193×10^8	0	0	0.0193×10^8
Regulatory Alternative 1	198	0	0.0193×10^8	0	0	0.0193×10^8
Wastewater systems						
MACT Floor	0	0	0	0	0	0
Regulatory Alternative 1	0.089×10^6	119×10^6	8.63×10^8	0	$1,750 \times 10^8$	$1,760 \times 10^8$
Bag dumps and process dryers						
MACT Floor	0	0	0	0	0	0

A. Electricity

Electricity would be needed to operate control devices used to control emissions from process vents, small storage tanks, and wastewater systems. As noted above, electricity was assumed to be generated in coal-fired boilers at utility plants. The amount of fuel energy required to generate the electricity was estimated using a heating value of 14,000 Btu/lb of coal and a power plant efficiency of 35 percent.

Specifically, electricity would be needed to operate the fans for incinerators, scrubbers, and condensers; the refrigeration unit for condensers; and pumps for scrubbers, condensers, and steam strippers. The power requirements for these devices were estimated using procedures in the OAQPS Control Cost Manual.[11] No additional electricity would be needed to operate floating roofs for storage tanks or to implement an LDAR program for equipment leaks. In addition, no additional electricity is needed to control emissions from bag dumps and product dryers because the MACT floor is equivalent to baseline.

B. Fuel

Fuel would be needed to operate incinerators and to generate steam for steam strippers. In both cases, natural gas was assumed to be the fuel of choice. No additional fuel would be needed to operate condensers for process vents, to operate condensers or floating roofs for storage tanks, or to implement an LDAR program for equipment leaks. In addition, no fuel would be needed to control emissions from bag dumps and product dryers because the MACT floor is equivalent to baseline. The fuel requirements for each control device are included in the control device cost algorithms, which are attachments to the Cost Impacts memorandum.[9]

The amount of natural gas needed in incinerators was estimated using mass and energy balances around the incinerators. The operating temperature was assumed to be 1600°F. Energy losses were assumed to be equal to 10 percent of the total energy input. Additional details on the procedure are described in the OAQPS Control Cost Manual.[12]

Steam strippers for wastewater streams were designed with an assumed wastewater-to-steam ratio of 10.4:1. The steam was assumed to be at 350°F and 100 psia. The enthalpy change was estimated to be 1,180 Btu per pound of steam, assuming the feed water to the boiler is at 50°F. The energy required to generate the steam was estimated assuming a boiler efficiency of 80 percent. The quantity of natural gas needed to supply the energy was estimated assuming the heating value of natural gas is 1,000 Btu per standard cubic foot.

VI. References

1. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 30, 1997. MACT Floor and Regulatory Alternatives for the Pesticide Active Ingredient Production Industry.

2. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 15, 1997. Summary of Data from Responses to Information Collection Requests and Site Visits for the Production of Pesticide Active Ingredients NESHAP.

3. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 30, 1997. Model Plants for the Pesticide Active Ingredient Production Industry.

4. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 30, 1997. Baseline Emissions for the Pesticide Active Ingredient Production Industry.

5. Protocol for Equipment Leak Emission Estimates. Office of Air Quality Planning and Standards. U. S. Environmental Protection Agency. EPA Document No. EPA-453/R-95-017. November 1995.

6. AP-42. 1995 Edition. pp. 1.4-3 and 1.4-4.

7. 40 CFR Part 60. Subpart Da.

8. AP-42. 1995 Edition. p. 1.1-3.

9. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 30, 1997. Cost Impacts of Regulatory Alternatives for the Pesticide Active Ingredient Production NESHAP.

10. OAQPS Control Cost Manual. Fourth Edition. EPA 450/3-90-006. January 1990. p. 9-53.

11. OAQPS Control Cost Manual. Fourth Edition. EPA 450/3-90-006. January 1990. pp. 3-55, 8-30, and 9-39.

12. OAQPS Control Cost Manual. Fourth Edition. EPA 450/3-90-006. January 1990. pp. 3-31 and 3-32.

Attachment 1

PROCESS VENT EMISSIONS

PAI NESHAP

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Plant no.	Process no.	B/C	No. models (a)	Uncontrolled emissions, Mg/yr: Chlorinated organics	Unchlor-inated	HCl	Other	Total	Baseline control: Organics eff., %	HCl eff., %	Baseline emissions, Mg/yr: Chlorinated organics	Unchlor-inated	HCl	Other	Total	MACT Floor vs. Baseline incremental reduction, Mg/yr: Organics	HCl	Regulatory alternative 1 vs. Baseline incremental reduction, Mg/yr: Organics	HCl	Regulatory alternative 2 vs. Baseline incremental reduction, Mg/yr: Organics	HCl
1	1	C		1.11	135	0.633	0	137	41.5	50.0	1.11	78.7	0.317	0	80.1	66.2		66.2		77.1	
1	2	C		0.0459	5.59	0.0262	0	5.66	41.5	50.1	0.0459	3.25	0.0131	0	3.31	2.73		2.73		3.18	
1	3	C		0.158	19.3	0.0904	0	19.5	41.5	50.0	0.158	11.2	0.0452	0	11.4	9.44		9.44		11.0	
1	4	C		0.0751	9.14	0.0428	0	9.26	41.5	49.9	0.0751	5.32	0.0214	0	5.42	4.47		4.47		5.21	
3	6	C		50.9	0	0	0	50.9	96.0		2.03	0	0	0	2.03					1.011	
3	7	B		0.693	0	0	0	0.693	0.0		0.693	0	0	0	0.693	0.624		0.624		0.679	
3	9	B		0	0.0245	0	0	0.0245	0.0		0	0.0245	0	0	0.0245						
3	11	B		0	0.403	9.00	0	9.41	98.0	99.0	0	0.00806	0.0900	0	0.0981						
3	12	B		0	0.782	0	0	0.782	90.0		0	0.0780	0	0	0.0780					0.062	
3	13	B		0	0.0676	0	0	0.0676	0.0		0	0.0676	0	0	0.0676						
5	14	C		0	0.916	0	0	0.916	97.0		0	0.0272	0	0	0.0272					0.009	
5	15	B		42.8	9.05	0	0	51.9	0.0		42.8	9.05	0	0	51.9	46.7		50.8		50.8	
6	16	B		0	16.5	0	0	16.5	90.0		0	1.65	0	0	1.65					1.32	
7	17	B		0	33.0	0	0	33.0	98.0		0	0.660	0	0	0.660						
7	18	C		0.181	12.6	0	0	857	0.0		0.181	12.6	0	0	21.3	11.5		11.5		12.6	
8	19	C		0.0431	202	13.2	0	215	93.6	90.0	0.0431	12.9	1.32	0	14.3		0.527		0.527	8.92	1.19
8	20	B		0.0454	15.2	6.80	0	22.1	90.0	90.0	0.00454	1.52	0.680	0	2.21		0.272		0.272	1.22	0.612
8	22	B		0	1.41		0	1.41	90.0		0	0.141		0	0.141					0.112	
8	23	C		0	0	14.5	0	14.5		91.7	0	0	1.21	0	1.21		0.3		0.3		1.1
9	24	B		0	0	356	0	356		99.9	0	0	0.356	0	0.356						
9	25	C		18.2	0	174	0	192	98.0	99.9	0.364	0	0.174	0	0.538						
10	26	B		0.00499	0	0	0	0.00499	99.9		4.99E-06	0	0		4.99E-06						
10	27	C		31.3	0	0	1.39	32.7	26.6		23.0	0	0.000907	0.274	23.2	19.8		22.3		22.3	
11	28	B/C		0	16.1	0	0	16.1	66.9		0	5.33	0	0	5.33	3.72		3.72		5.01	
11	29	B/C		0	59.5	0	0	59.5	66.9		0	19.7	0	0	19.7	13.8		13.8		18.5	
11	30	B/C		0	48.3	0	0	48.3	66.9		0	16.0	0	0	16.0	11.2		11.2		15.0	
11	31	B/C		40.7	51.5	0	0	92.2	56.6		18.2	21.8	0	0	40.0	30.8		30.8		38.2	
11	32	B/C		103	7.52	1.30	0	112	91.9	99.0	2.05	6.87	0.0130	0	8.94					6.71	
11	33	C		60.3	4.41	0.761	0	65.5	91.9	99.0	1.21	4.04	0.00761	0	5.25					3.96	
11	34	B/C		0	0.354	0	0	0.354	98.0		0	0.00708	0	0	0.00708						
11	35	B/C		0	0.154	0	0	0.154	98.0		0	0.00310	0	0	0.00310						
11	36	B		0	0.399	0	0	0.399	98.0		0	0.00798	0	0	0.00798						
12	37	B		0	4.59	11.0	0	15.6	98.0	99.0	0	0.0918	0.110	0	0.202						
12	38	B		0	24.3	0.000136	7.71	32.0	97.4	99.0	0	0.632	1.36E-06	0.00860	0.641					0.146	
12	39	C		199	0	67.2	0	266	97.0	98.5	5.93	0	1.03	0	6.96					2.0	0.359
12	40	B		32.8	15.4	26.7	0	74.9	93.5	99.8	0.919	2.19	0.0667	0	3.18					2.15	
13	42	B/C		0	18.9	0	0	18.9	96.5		0	0.668	0	0	0.668					0.289	
14	43	B		0	1.74	0	0	1.74	98.0		0	0.0345	0	0	0.0345						
14	44	B		0	1.76	0	0	1.76	98.0		0	0.0351	0	0	0.0351						

PROCESS VENT EMISSIONS

PAI NESHAP

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Plant no.	Process no.	B/C	No. models (a)	Uncontrolled emissions, Mg/yr: Chlorinated organics	Unchlor-inated	HCl	Other	Total	Baseline control: Organics eff., %	HCl eff., %	Baseline emissions, Mg/yr: Chlorinated organics	Unchlor-inated	HCl	Other	Total	MACT Floor vs. Baseline incremental reduction, Mg/yr: Organics	HCl	Regulatory alternative 1 vs. Baseline incremental reduction, Mg/yr: Organics	HCl	Regulatory alternative 2 vs. Baseline incremental reduction, Mg/yr: Organics	HCl
14	45	B		0	3.19	0	0	3.19	98.0		0	0.0642	0	0	0.0642						
14	46	B		0	1.00	0	0	1.00	98.0		0	0.0199	0	0	0.0199						
14	47	B		0	2.28	0	0	2.28	98.0		0	0.0458	0	0	0.0458						
15	48	B		0	0.0133	5.90E-05	0	0.0134	0.0	0.0	0	0.0133	5.90E-05	0	0.0134						
15	49	B		0	0.00127	0	0	0.00127	0.0		0	0.00127	0	0	0.00127						
15	50	B		0	0.0237	0	0	0.0237	0.0		0	0.0237	0	0	0.0237						
15	51	B		0	0.0474	0	0	0.0474	70.0		0	0.0142	0	0	0.0142						
15	52	B		0	0	9.80E-06	0	9.80E-06		0.0	0	0	9.80E-06	0	9.80E-06						
15	54	B		0	1.59	0.157	0	1.74	0.0	0.0	0	1.59	0.157	0	1.74	1.43		1.43		1.56	
15	55	B		0	0.000245	0.000962	0	0.00121	0.0	0.0	0	0.000245	0.000962		0.00121						
15	56	B		0	0.0855	0	0	0.0855	0.0		0	0.0855			0.0855						
15	57	B		0	0.276	0	0	0.276	0.0		0	0.276	0	0	0.276	0.248		0.248		0.270	
15	58	B		0	0.679	0	0	0.679	0.0		0	0.679	0	0	0.679	0.611		0.611		0.666	
16	59	B		0	0	0	0	0			0	0	0	0	0						
17	60	B		0.337	0	0	0	0.337	98.0		0.00674	0	0	0	0.00674						
17	61	C		0	8.19	0	0	8.19	98.0		0	0.164	0	0	0.164						
17	62	C		0	15.3	0	0	15.3	81.0		0	2.91	0	0	2.91	1.380		1.380		2.60	
17	63	C		0	200	0	0	200	97.4		0	5.22	0	0	5.22					1.22	
19	64	B		0	34.3	0	0	34.3	99.5		0	0.171	0	0	0.171						
20	65	B		0	0.146	0	0.0907	0.237	0.0		0	0.146	0	0.0907	0.237						
20	66	B		0	81.8	0	0.00260	81.8	99.0		0	0.807	0	0.00260	0.807						
21	67	B		0	129	12.0	0	141	50.6	80.4	0	63.5	2.36	0	65.9	50.7	1.64	60.9	1.64	60.9	2.24
21	68	B		0	28.5	0	0	28.5	85.5		0	4.14	0	0	4.14	1.29		1.29		3.57	
21	69	B		0	5.81	0	0	5.81	83.9		0	0.938	0	0	0.938	0.357		0.357		0.822	
21	70	B		0	0.447	0	0	0.447	85.5		0	0.0650	0	0	0.0650	0.020		0.020		0.056	
21	71	B		0	0.820	0	0	0.820	85.5		0	0.119	0	0	0.119	0.037		0.037		0.103	
21	72	B		0	0.857	0	0	0.857	85.5		0	0.125	0	0	0.125	0.039		0.039		0.107	
21	73	B		0	0.969	0	0	0.969	85.5		0	0.141	0	0	0.141	0.044		0.044		0.121	
22	74	C		347	0	2,360	0	2,707	98.0	99.0	6.94	0	23.7	0	30.6						0.1
22	75	B		53.1	0	349	0	402	98.0	99.0	1.06	0	3.66	0	4.72						0.171
22	76	B		0	4.54	0	0	4.54	98.0		0	0.0907	0	0	0.0907						
22	77	B		0	4.54	0	0	4.54	98.0		0	0.0907	0	0	0.0907						
22	78	B		0	23.8	0	0	23.8	98.0		0	0.475	0	0	0.475						
22	79	B		8.30	0	54.4	0	62.8	98.0	99.0	0.166	0	0.567	0	0.733						0.0
22	80	C		0	1.81	0	0	1.81	98.0		0	0.0363	0	0	0.0363					0.0	
22	81	B		0	1.38	0	0	1.38	98.0		0	0.0276	0	0	0.0276						
22	82	B		45.4	12.2	0	0	57.5	98.0		0.907	0.242	0	0	1.15						
22	83	B		22.7	6.27	0	0	28.9	98.0		0.454	0.125	0	0	0.579						
22	84	B		0	96.3	0.101	0	96.4	98.0	0.0	0	1.93	0.101	0	2.03						

PROCESS VENT EMISSIONS

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Plant no.	Process no.	B/C	No. models (a)	Uncontrolled emissions, Mg/yr: Chlorinated organics	Unchlor-inated	HCl	Other	Total	Baseline control: Organics eff., %	HCl eff., %	Baseline emissions, Mg/yr: Chlorinated organics	Unchlor-inated	HCl	Other	Total	MACT Floor vs. Baseline incremental reduction, Mg/yr: Organics	HCl	Regulatory alternative 1 vs. Baseline incremental reduction, Mg/yr: Organics	HCl	Regulatory alternative 2 vs. Baseline incremental reduction, Mg/yr: Organics	HCl
22	85	B		0	66.7	0	0	66.7	98.0		0	1.33	0	0	1.33						
22	86	B		1,725	0	535	0	2,260	98.0	50.1	34.5	0	267	0	302		235		235		262
23	87	B		0	0.00953	0	0	0.00953	0.0		0	0.00953	0	0	0.00950						
23	88	B		0.00181	0.0499	0.104	0	0.156	70.0	97.0	0.000543	0.0150	0.00310		0.0186						
23	89	B		0.0132	0.342	0.710	0	1.07	70.0	97.1	0.00408	0.103	0.0209	0	0.127	0.071		0.071		0.099	
23	90	B		0.00771	0.198	0.410	0	0.616	70.0	97.0	0.00227	0.0594	0.0122	0	0.0739	0.041		0.041		0.058	
23	91	C		4.02	0	117	0	121	65.7	99.0	1.38	0	1.17	0	2.55	0.978		0.978		1.30	
23	92	B		0.486	1.39	0.000950	0	1.88	98.0	100.0	0.00971	0.0279	0	0	0.0376						
23	93	B		40.1	18.6	0.557	0	59.2	76.9	97.4	7.65	5.90	0.0146	0	13.6	7.68		7.68		12.4	
23	94	B		26.5	38.5	33.1	0	98.1	76.7	98.9	3.35	11.8	0.357	0	15.5	8.66		8.66		13.9	0.0
Model 1 (b)			42	0	575	0		575	80.0		0	115	0		115	57.5		57.5		104	
Model 1 (c)			6	0	82.2	0		82	80.0		0	16.4	0		16.4	8.22		14.8		14.8	
Model 2 (b)			4	83.6	76.4	264		424	80.0	80.0	16.7	15.3	52.9		84.9	16.0	37.0	16.0	37.0	28.8	50.2
Model 2 (b)			8	167	153	529		849	80.0	99.0	33.4	30.6	5.29		69.3	32.0		32.0		57.6	
Model 2 (c)			2	41.8	38.2	132		212	80.0	80.0	8.36	7.64	26.4		42.4	8.00	18.5	14.4	18.5	14.4	25.1
Model 2 (c)			5	105	95.5	331		531	80.0	99.0	20.9	19.1	3.31		43.3	20.0		36.0		36.0	
Model 3 (b)			13	0	533	0		533	80.0		0	107	0		107	53.3		53.3		95.9	
Model 3 (c)			1	0	41.0	0		41	80.0		0	8.20	0		8.20	4.10		7.38		7.38	
Model 4 (b)			1	79	22.9	295		397	80.0	80.0	15.8	4.58	59		79	10.2	41.3	10.2	41.3	18.3	56
Model 4 (b)			5	395	114.5	1,475		1,984	80.0	99.0	78.9	22.9	14.8		116.6	50.9		50.9		91.6	
Model 4 (c)			3	237	68.7	885		1,190	80.0	80.0	47.3	13.74	177		238	30.5	123.9	55.0	123.9	55.0	168
Model 4 (c)			3	237	68.7	885		1,190	80.0	99.0	47.3	13.7	8.9		69.9	30.5		55.0		55.0	
			93	4,198	3,377	8,940	9.19	16,524			424	692	652	0.375	1,769	616	458	714	458	966	567

(a) The population of each of the four model processes is provided in the Model Plants memorandum. The percentage of model processes that require HCl control is provided in the Baseline Emissions memorandum.

The number of model processes that satisfy the applicability criteria for 98 percent control under Regulatory Alternative 1 is described in the Cost Impacts memorandum.

(b) Emissions stream characteristics do not satisfy the applicability criteria for 98 percent control of organic HAP emissions for Regulatory Alternative 1.

(c) Emission stream characteristics satisfy the applicability criteria for 98 percent control of organic HAP emissions for Regulatory Alternative 1.

Attachment 2

UNCONTROLLED EMISSION FACTORS AND REGULATORY ALTERNATIVE 1 EMISSION FACTORS FOR EQUIPMENT LEAKS
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\ELEAKS\ELFACTOR.XLS

BATCH MODEL

Processes	Number of components	Average SOCMI emission factor, kg/hr/component	Hours of operation, hr/yr	Uncontrolled (or Baseline) emissions, kg/yr	Control Efficiency for LDAR, %	Regulatory alternative 1 emissions, kg/yr
FLANGES	1,100	0.00183	2,800	5,636	0.93	394.5
PUMPS	14	0.0199	2,800	780.1	0.75	195.0
GAS VALVES	65	0.00597	2,800	1,087	0.92	86.9
LIQUID VALVES	340	0.00403	2,800	3,837	0.88	460.4
				11,340 kg/yr		1,137 kg/yr
				11.34 Mg/yr		1.137 Mg/yr

CONTINUOUS MODEL

Processes	Number of components	Average SOCMI emission factor, kg/hr/component	Hours of operation, hr/yr	Uncontrolled (or Baseline) emissions, kg/yr	Control Efficiency for LDAR, %	Regulatory alternative 1 emissions, kg/yr
FLANGES	1,500	0.00183	5,000	13,725	0.93	960.7
PUMPS	33	0.0199	5,000	3,284	0.75	820.9
GAS VALVES	240	0.00597	5,000	7,164	0.92	573.1
LIQUID VALVES	1,100	0.00403	5,000	22,165	0.88	2,659.8
				46,338 kg/yr		5,015 kg/yr
				46.34 Mg/yr		5.015 Mg/yr

EQUIPMENT LEAK EMISSION REDUCTION FOR MACT FLOOR AND REGULATORY ALTERNATIVE
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\ELEAKS\EL-EMRED.XLS

Regulatory Alternative	Baseline Emissions (Mg/yr)	ER From Baseline (Mg/yr)	ER From Baseline (%)
MACT floor	3,407	0	0
Subpart H	3,407	3,022	88.7%

Processes	Number of processes	Emissions per process Mg/yr/process				Nationwide emissions, Mg/yr			
		Uncontrolled (a)	Baseline (a)	MACT Floor	After subpart H (a)	Uncontrolled	Baseline	MACT Floor	After subpart H
Batch EL model	138	11.34	11.34	11.34	1.137	1,565	1,565	1,565	157
Continuous EL model	37	46.34	46.34	46.34	5.015	1,715	1,715	1,715	186
Process 1	1	1.78	1.43	1.43	0.093	1.78	1.43	1.43	0.093
Process 4	1	0.56	0.56	0.56	0.044	0.56	0.56	0.56	0.044
Process 20	1	14.2	10.7	10.7	1.10	14.2	10.7	10.7	1.10
Process 23	1	42.1	29.2	29.2	4.79	42.1	29.2	29.2	4.79
Process 24	1	2.80	1.95	1.95	0.319	2.80	1.95	1.95	0.319
Process 25	1	6.01	4.17	4.17	0.684	6.01	4.17	4.17	0.684
Process 26	1	6.01	4.17	4.17	0.684	6.01	4.17	4.17	0.684
Process 10	1	2.64	2.64	2.64	0.239	2.64	2.64	2.64	0.239
Process 22	1	2.02	2.02	2.02	0.164	2.02	2.02	2.02	0.164
Process 14	1	1.27	1.27	1.27	0.106	1.27	1.27	1.27	0.106
Process 11	1	24.1	24.1	24.1	2.07	24.1	24.1	24.1	2.07
Process 13	1	7.06	7.06	7.06	0.625	7.06	7.06	7.06	0.625
Process 6	1	3.09	3.08	3.08	0.282	3.09	3.08	3.08	0.282
Process 9	1	3.79	3.79	3.79	0.368	3.79	3.79	3.79	0.368
Implementing subpart H	14	21.7	2.26	2.26	2.26	304	31.6	31.6	31.6
	203					3,701	3,407	3,407	386

(a) Uncontrolled, Baseline, and Regulatory Alternative emissions for all except the model processes are estimated in an attachment to the Baseline emissions memorandum (the attachment is CBI). The emissions for the model processes are discussed in the Model Plant memorandum.

Attachment 3

STORAGE TANK EMISSIONS AT BASELINE, MACT FLOOR, AND REGULATORY ALTERNATIVE

PAI NESHAP FILE: F:\PROJECT\AGCHEMS\TANKS\ST-EMRED.XLS

	NO. TANKS	UNCONTROLLED EMISSIONS/ TANK, LB/YR	NATIONWIDE UNCONTROLLED EMISSIONS, LB/YR	BASELINE CONTROL EFF.	NATIONWIDE BASELINE EMISSIONS, LB/YR	MACT FLOOR CONTROL DEVICE	MACT FLOOR CONTROL EFF.	NATIONWIDE MACT FLOOR EMISSIONS, LB/YR	REGULATORY ALTERNATIVE CONTROL DEVICE	REGULATORY ALTERNATIVE CONTROL EFF.	NATIONWIDE REG ALT EMISSIONS, LB/YR
SURVEYED TANKS											
Basis of Model 1-A	9		12,702	98.00%	254	NONE		254	NONE		254
(9 TANKS)											
Basis of Model 1-B	5		2,728	0.00%	2,728	CONDENSER	41%	1,610	CONDENSER	41%	1,610
(9 TANKS)	1		1,219	4.00%	1,170	CONDENSER	41%	690	CONDENSER	41%	690
	1		509	13.20%	442	CONDENSER	41%	261	CONDENSER	41%	261
	1		259	41.00%	153	NONE		153	NONE		153
	1		574	42.00%	333	NONE		333	NONE		333
Basis of Model 1-C	12		451	0.00%	451	NONE		451	NONE		451
(23 TANKS)	1		101	89.00%	11	NONE		11	NONE		11
	3		267	90.00%	27	NONE		27	NONE		27
	1		99	95.00%	5	NONE		5	NONE		5
	5		532	98.00%	11	NONE		11	NONE		11
	1		122	99.50%	1	NONE		1	NONE		1
Basis of Model 2-A	8		7,374	98.00%	147	NONE		147	NONE		147
(8 TANKS)											
Basis of Model 2-B	2		2,422	0.00%	2,422	IFR	41%	1,429	IFR	95%	121
(2 TANKS)											
Basis of Model 2-C	9		296	0.00%	296	NONE		296	NONE		296
(11 TANKS)	2		113	98.00%	2	NONE		2	NONE		2
Basis of Model 3-A	4		72,912	95.00%	3,646	NONE		3,646	NONE		3,646
(12 TANKS)	8		14,301	98.00%	286	NONE		286	NONE		286
Basis of Model 3-B	3		5,347	0.00%	5,347	IFR	41%	3,155	IFR	95%	267
(4 TANKS)	1		2,380	25.00%	1,785	IFR	41%	1,053	IFR	95%	89
Basis of Model 3-C	2		364	0.00%	364	NONE		364	NONE		364
(4 TANKS)	2		275	98.00%	5	NONE		5	NONE		5

STORAGE TANK EMISSIONS AT BASELINE, MACT FLOOR, AND REGULATORY ALTERNATIVE

PAI NESHAP FILE: F:\PROJECT\AGCHEMS\TANKS\ST-EMRED.XLS

	NO. TANKS	UNCONTROLLED EMISSIONS/ TANK, LB/YR	NATIONWIDE UNCONTROLLED EMISSIONS, LB/YR	BASELINE CONTROL EFF.	NATIONWIDE BASELINE EMISSIONS, LB/YR	MACT FLOOR CONTROL DEVICE	MACT FLOOR CONTROL EFF.	NATIONWIDE MACT FLOOR EMISSIONS, LB/YR	REGULATORY ALTERNATIVE CONTROL DEVICE	REGULATORY ALTERNATIVE CONTROL EFF.	NATIONWIDE REG ALT EMISSIONS, LB/YR
MODELLED TANKS											
Model 1-A (26 TANKS)	26	1,411.33	36,695	95.00%	1,835	NONE		1,835	NONE		1,835
Model 1-B (26 TANKS)	26	587.82	15,283	11.00%	13,602	CONDENSER	41%	8,025	CONDENSER	41%	8,025
MODEL 1-C (67 TANKS)	67	68.34	4,579	45.00%	2,518	NONE		2,518	NONE		2,518
Model 2-A (23 TANKS)	23	921.79	21,201	95.00%	1,060	NONE		1,060	NONE		1,060
Model 2-B (6 TANKS)	6	1,210.95	7,266	0.00%	7,266	IFR	41%	4,287	IFR	95%	363
Model 2-C (32 TANKS)	32	37.17	1,189	18.00%	975	NONE		975	NONE		975
Model 3-A (34 TANKS)	34	7,267.74	247,103	95.00%	12,355	NONE		12,355	NONE		12,355
Model 3-B (12 TANKS)	12	1,931.64	23,180	6.00%	21,789	IFR	41%	12,855	IFR	95%	1,089
Model 3-C (12 TANKS)	12	159.71	1,917	50.00%	958	NONE		958	NONE		958
TOTAL	320		483,759.89 LB 219.43 MG		82,244.77 LB 37.31 MG			59,058.82 LB 26.79 MG			38,210.44 LB 17.33 MG

Attachment 4

WASTEWATER EMISSIONS FOR MACT FLOOR AND REGULATORY ALTERNATIVE
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\WW-IMPAX\WW-EMRED.WQ2

								REGULATORY ALTERNATIVE (a)							
	Stream (b)	Flow rate per stream, gal/yr	Load per stream, Mg/yr	ppmw	Baseline and MACT Floor emissions, Mg/yr	Fr	Fe	Removed from load per stream, Mg/yr	Left in water per stream, Mg/yr	Emissions per stream after SS, Mg/yr	Reduction from baseline per stream, Mg/yr	Number of streams to control nationwide	Nationwide baseline and MACT floor, Mg/yr	Nationwide reduction from baseline, Mg/yr	Nationwide flowrate to SS, gal/yr
1	13a, 14a, 15a	6,990,000	158	5,971	88.4	0.99	0.56	156	1.58	0.884	87.5	1	88.4	87.5	6,990,000
2	17b	5,040,000	479	25,123	306	0.99	0.64	474	4.79	3.07	303	1	306	303	5,040,000
3	18b	2,960,000	281	25,095	180	0.99	0.64	278	2.81	1.80	178	1	180	178	2,960,000
4	27	120,000	13.6	29,958	10.9	0.99	0.8	13.5	0.136	0.109	10.8	3	32.7	32.4	360,000
5	32	1,857,146	10.7	1,523	8.57	0.99	0.8	10.6	0.107	0.0856	8.48	2	17.1	17.0	3,714,292
6	plant 15	1,865,855	11.6	1,647	9.30	0.99	0.8	11.5	0.116	0.0930	9.21	1	9.30	9.21	1,865,855
7	26	4,000,000	51.3	3,390	24.6	0.95	0.48	48.7	2.57	1.23	23.4	2	49.2	46.7	8,000,000
8	20	1,819,000	8.94	1,299	3.46	0.544	0.387	4.86	4.08	1.58	1.88	1	3.46	1.88	1,819,000
9	16a,b	5,600,000	1,144	54,001	326	0.44	0.286	504	641	183	143	1	326	143	5,600,000
10	37e,f,g,j,k	40,357,268	485	3,175	93.4	0.335	0.193	162	322	62.2	31.2	1	93.4	31.2	40,357,268
11	38a	5,250,000	90.9	4,577	17.5	0.335	0.193	30.5	60.5	11.7	5.83	1	17.5	5.83	5,250,000
12	42	3,513,600	143	10,759	26.1	0.323	0.182	46.2	96.8	17.6	8.48	1	26.1	8.48	3,513,600
13	43	885,600	35.9	10,716	6.98	0.336	0.194	12.1	23.8	4.63	2.35	1	6.98	2.35	885,600
14	44	695,665	34.1	12,957	8.70	0.402	0.255	13.7	20.4	5.20	3.50	1	8.70	3.50	695,665
15	plant 21	45,607,268	576	3,336	111	0.335	0.193	193	383	73.9	37.2	1	111	37.2	45,607,268
16	plant 22	5,094,865	213	11,051	41.7	0.338	0.196	72.0	141	27.6	14.1	1	41.7	14.1	5,094,865
17	19+20+21	10,700,000	52.6	1,300	20.4	0.544	0.387	28.6	24.0	9.29	11.1	1	20.4	11.1	10,700,000
18	29	5,625	0.349	16,392	0.279	0.99	0.8	0.345	0.0035	0.0028	0.276	1	0.279	0.276	5,625
19	30	1,028	0.192	49,338	0.154	0.99	0.8	0.190	0.0019	0.0015	0.152	1	0.154	0.152	1,028
20	31	2,056	0.385	49,513	0.308	0.99	0.8	0.381	0.0039	0.0031	0.305	1	0.308	0.305	2,056
21	7	11,600	1.23	28,033	0.209	0.31	0.17	0.381	0.849	0.144	0.0647	3	0.627	0.194	34,800
22	23	47,000	1.81	10,179	0.308	0.31	0.17	0.561	1.25	0.212	0.0956	3	0.924	0.287	141,000
														934	148,637,922

(a) Regulatory alternative emissions are based on the assumption that a steam stripper is used to control emissions.
(b) Streams at surveyed plants 15, 21, and 22 combined for control with one stream stripper at each facility; still separate stream strippers for each stream at modelled plants.
Combined streams 19, 20, and 21 at a modelled plant because of their relationship to each other at the surveyed plant.
Combined streams 13a, 14a, and 15a at a modelled plant because of their relationship at the surveyed plant.

Attachment 5

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Process Vents - Secondary Air Environmental Impacts

21-Apr-97

The electricity and natural gas requirements for each of the models are based on the control device design algorithms that are discussed in the Cost Impacts Memorandum. See sections V.A and B for discussions of electricity and fuel calculations and section IV.A for discussion of emission factors used to estimate secondary air impacts from fuel combustion.

EXAMPLE MODEL 1D:

Calculate amount of coal burned to generate electricity required, assuming 35 percent heat to energy conversion:

2,666,070 Kw-hr/yr x 3,412 Btu/Kw-hr / 14,000 Btu/lb coal / 2, 000 lb coal/ton coal / 0.35 = 928 tons coal/yr

Calculate amount of coal Btu's burned to generate electricity required, assuming 35 percent heat to energy conversion:

2,666,070 Kw-hr/yr x 3,412 Btu/Kw-hr / 0.35 = 25,990,373,829 Btu/yr

Emissions of CO:

928 ton coal/yr x 5 lb CO/ton coal / 2204 lb/Mg + 372,673,584 scf nat. gas x 35 lb CO/10^6 scf nat. gas / 2204 lb/Mg = 8.03 Mg CO/yr

Emissions of NOx:

928 ton coal/yr x 13.7 lb NOx/ton coal / 2204 lb/Mg + 372,673,584 scf nat. gas x 140 lb NOx/10^6 scf nat. gas / 2204 lb/Mg = 29.5 Mg NOx

Emissions of SO2:

First, convert the emission factor: 1.2 lb SO2/10^6 Btu x 14,000 Btu/lb coal x 2,000 lb coal/ton coal = 33.6 lb SO2/ton coal

928 ton coal/yr x 33.6 lb SO2/ton coal / 2204 lb/Mg + 372,673,584 scf nat. gas x 0.6 lb SO2/10^6 scf nat. gas / 2204 lb/Mg = 14.3 Mg SO2/y

Emissions of PM:

First, convert the emission factor: 0.03 lb SO2/10^6 Btu x 14,000 Btu/lb coal x 2,000 lb coal/ton coal = 0.84 lb SO2/ton coal

928 ton coal/yr x 0.84 lb PM/ton coal / 2204 lb/Mg + 372,673,584 scf nat. gas x 6.2 lb PM/10^6 scf nat. gas / 2204 lb/Mg = 1.40 Mg PM/yr

Conversion Data:			
Utility Plant NSPS Subpart Da, 40 CFR part 60		3,412	Btu/Kw-hr
		14,000	Btu/lb coal
		1000	Btu/scf nat gas
1.2	lb SO2/10^6 Btu (controlled)	1.80	% sulfur in coal
0.03	lb PM/10^6 Btu (controlled)	35%	pp eff.
AP-42 Emission factors			
5	lb CO/ton coal		
13.7	lb NOx/ton coal		
35	lb CO/10^6 ft3 nat. gas (unc.):		
140	lb NOx/10^6 ft3 nat. gas (unc.):		
6.2	lb PM/10^6 ft3 nat. gas (unc.):		
0.6	lb SO2/10^6 ft3 nat. gas (unc.):		

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Wastewater - Energy Impacts

15-Jul-97

The electricity and natural gas requirements are based on the control device design algorithms that are discussed in the Cost Impacts Memorandum. See sections V.A and B for discussions of electricity and fuel calculations and section IV.A for discussion of emission factors used to estimate secondary air impacts from fuel combustion. The secondary air impacts are calculated by the same method as for process vents.

EXAMPLE:

Calculate the actual steam used for stripping HAP from wastewater:

148,000,000 gal H2O/yr x 8.33 lb/gal H2O / 10.4 lb water/lb steam = 118,542,308 lb steam

Calculate the energy needed to generate the steam required, assuming 80 percent boiler efficiency:

148,000,000 gal H2O/yr x 8.33 lb/gal H2O / 10.4 lb water/lb steam x 1,180 Btu/lb steam / 0.80 = 174,849,903,846 Btu/yr

Calculate the amount of natural gas required to generate steam required:

174,849,903,846 Btu/yr / 1,000 Btu/scf nat gas = 174,849,903.8 scf nat. gas

Calculate amount of electricity required to run the strippers, assuming 64 percent pump efficiency:

148,000,000 gal H2O/yr x 122 ft H2O x 8.33 lb/gal H2O / 0.00182 hp-s/ft-lb / 3600 sec/hr x 0.7457 kW/hp / 0.64 = 88,503 kW-hr/yr

Calculate amount of coal required to generate electricity required, assuming 35 percent heat to energy conversion:

88,503 Kw-hr/yr x 3,413 Btu/Kw-hr / 14,000 Btu/lb coal / 2,000 lb/ton / 0.35 = 30.82 tons coal/yr

Conversion Data:	
Utility Plant NSPS Subpart Da, 40 CFR part 60 1.2 lb SO2/10^6 Btu (controlled) 0.03 lb PM/10^6 Btu (controlled)	3,412 Btu/Kw-hr 14,000 Btu/lb coal 1000 Btu/scf nat gas 1.80 % sulfur in coal 35% pp eff.
AP-42 Emission factors 5 lb CO/ton coal 13.7 lb NOx/ton coal 35 lb CO/10^6 ft3 nat. gas (unc.) 140 lb NOx/10^6 ft3 nat. gas (unc.) 6.2 lb PM/10^6 ft3 nat. gas (unc.) 0.6 lb SO2/10^6 ft3 nat. gas (unc.)	

PAI NESHAP FILE: PROJECT\AGCHEMS\PVENTS\EI2_MF.WQ1

Process Vents Environmental Impacts - MACT floor

30-Apr-97

Data:

Model (a)	Control Device	Natural gas, scf/yr/model	Electricity, kwh/yr/model	Number of models	Nationwide electricity, kwh/yr	Nationwide auxiliary natural gas, scf/yr	Coal burned to generate electricity, ton/yr	Coal burned to generate electricity, Btu/yr	Mg CO/yr	Mg NOx/yr	Mg SO2/yr	Mg PM/yr
1d	incinerator	20,704,088	148,115	18	2,666,070	372,673,584	928	25,990,373,829	8.03	29.5	14.3	1.40
1c	condenser	0	265,157	43	11,401,751		3,970	111,150,784,034	9.01	24.7	60.6	1.51
2d (HCl 80%)	incinerator/scrubber	13,892,987	108,536	5	542,680	69,464,935	189	5,290,354,743	1.53	5.59	2.90	0.268
2d (HCl 94%)	incinerator	13,892,987	104,434	11	1,148,774	152,822,857	400	11,198,905,394	3.34	12.2	6.14	0.583
2c (HCl 80%)	scrubber/condenser	0	19,516	2	39,032		14	380,506,240	0.031	0.085	0.207	0.005
2c (HCl 94%)	condenser	0	19,449	6	116,694		41	1,137,599,794	0.092	0.253	0.620	0.015
3d	incinerator	166,068,810	1,177,836	13	15,311,868	2,158,894,530	5,331	149,268,838,903	46.4	170	81.9	8.11
3c	condenser	0	44,898	8	359,184		125	3,501,530,880	0.284	0.778	1.91	0.048
4d (HCl 80%)	incinerator/scrubber	131,310,794	979,978	3	2,939,934	393,932,382	1,024	28,660,156,594	8.58	31.4	15.7	1.50
4d (HCl 94%)	incinerator	131,310,794	942,842	8	7,542,736	1,050,486,352	2,626	73,530,900,663	22.7	83.1	40.3	3.96
4c (HCl 80%)	scrubber/condenser	0	144,902	1	144,902		50	1,412,587,497	0.115	0.314	0.770	0.019
4c (HCl 94%)	condenser	0	144,546	3	433,638		151	4,227,351,017	0.343	0.939	2.30	0.058
4sd (HCl 80%)	scrubber	0	37,136	1	37,136		13	362,022,949	0.029	0.080	0.197	0.005
			TOTAL:		640,200,000	62,970,000,000			1507	5389	3418	262.3

(a) The HCl efficiency in parentheses is the baseline level of control for each model.

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Process Vents Environmental Impacts - Reg alt 1

30-Apr-97

Data:

Model (a)	Control Device	Natural gas, scf/yr/model	Electricity, kwh/yr/model	Number of Models	Nationwide electricity, Kw-hr/yr	Nationwide auxiliary natural gas, scf/yr	Coal burned to generate electricity, ton/yr	Coal burned to generate electricity, Btu/yr	Mg CO/yr	Mg NOx/yr	Mg SO2/yr	Mg PM/yr
1d	incinerator	20,704,088	148,115	18	2,666,070	372,673,584	928	25,990,373,829	8.03	29.5	14.3	1.40
1c	condenser	0	265,157	37	9,810,809		3,416	95,641,372,309	7.75	21.2	52.1	1.30
2d (HCl 80%)	incinerator/scrubber	13,892,987	108,536	3	325,608	41,678,961	113	3,174,212,846	0.920	3.35	1.74	0.161
2d (HCl 94%)	incinerator	13,892,987	104,434	10	1,044,340	138,929,870	364	10,180,823,086	3.03	11.1	5.58	0.530
2c (HCl 80%)	scrubber/condenser	0	19,517	1	19,517		6.80	190,262,869	0.015	0.042	0.104	0.003
2c (HCl 94%)	condenser	0	19,449	1	19,449		6.77	189,599,966	0.015	0.042	0.103	0.003
3d	incinerator	166,068,810	1,777,836	13	23,111,868	2,158,894,530	8,047	225,307,696,046	52.6	187	123	9.15
3c	condenser	0	44,898	7	314,286		109	3,063,839,520	0.248	0.681	1.67	0.042
4d (HCl 80%)	incinerator/scrubber	131,310,794	979,978	1	979,978	131,310,794	341	9,553,385,531	2.86	10.5	5.24	0.500
4d (HCl 94%)	incinerator	131,310,794	942,842	5	4,714,210	656,553,970	1,641	45,956,812,914	14.2	51.9	25.2	2.47
4c (HCl 80%)	scrubber/condenser	0	144,902	0	0		0.00	0	0.000	0.000	0.000	0.000
4c (HCl 94%)	condenser	0	144,546	2	289,092		101	2,818,234,011	0.228	0.626	1.54	0.038
4sd (HCl only)	scrubber	0	37,136	1	37,136		12.9	362,022,949	0.029	0.080	0.197	0.005
1c alt	condenser	0	378,417	6	2,270,502		791	22,134,150,926	1.79	4.92	12.1	0.301
2d alt (HCl 80%)	incinerator/scrubber	13,892,987	108,536	2	217,072	27,785,974	75.6	2,116,141,897	0.613	2.24	1.16	0.107
2d alt (HCl 94%)	incinerator	13,892,987	104,434	1	104,434	13,892,987	36.4	1,018,082,309	0.303	1.11	0.558	0.053
2c alt (HCl 80%)	scrubber/condenser	0	31,345	1	31,345		10.9	305,568,971	0.025	0.068	0.166	0.004
2c alt (HCl 94%)	condenser	0	31,277	5	156,385		54.4	1,524,530,343	0.124	0.339	0.831	0.021
3c alt	condenser	0	80,969	1	80,969		28.2	789,332,080	0.064	0.175	0.430	0.011
4d alt (HCl 80%)	incinerator/scrubber	131,310,794	979,978	2	1,959,956	262,621,588	682	19,106,771,063	5.72	20.9	10.5	1.00
4d alt (HCl 94%)	incinerator	131,310,794	942,842	3	2,828,526	393,932,382	985	27,574,087,749	8.50	31.2	15.1	1.48
4c alt (HCl 80%)	scrubber/condenser	0	205,895	1	205,895		71.7	2,007,182,114	0.163	0.446	1.09	0.027
4c alt (HCl 94%)	condenser	0	205,539	1	205,539		71.6	2,003,711,623	0.162	0.445	1.09	0.027
			TOTAL:		51,390,000	4,198,000,000			107	378	274	18.6

(a) The HCl efficiency in parentheses is the baseline level of control for each model.

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Process Vents Environmental Impacts - Reg alt 2

30-Apr-97

Data:

Model (a)	Control Device	Natural gas, scf/yr/model	Electricity, kwh/yr/model	Number of Models	Nationwide electricity, Kw-hr/yr	Nationwide auxiliary natural gas, scf/yr	Coal burne to generate electricity, ton/yr	Coal burned to generate electricity, Btu/yr	Mg CO/yr	Mg NOx/yr	Mg SO2/yr	Mg PM/yr
1d alt	incinerator	20,704,088	148,115	18	2,666,070	372,673,584	928	25,990,373,829	8.03	29.5	14.3	1.40
1c alt	condenser	0	378,417	37	14,001,429		4,875	136,493,930,709	11.1	30.3	74.4	1.86
2d alt (HCl 80%)	incinerator/scrubber	13,892,987	108,536	3	325,608	41,678,961	113	3,174,212,846	0.920	3.35	1.74	0.161
2d alt (HCl 94%)	incinerator	13,892,987	104,434	10	1,044,340	138,929,870	364	10,180,823,086	3.03	11.1	5.58	0.530
2c alt (HCl 80%)	scrubber/condenser	0	31,345	1	31,345		10.9	305,568,971	0.025	0.068	0.166	0.004
2c alt (HCl 94%)	condenser	0	31,277	1	31,277		10.9	304,906,069	0.025	0.068	0.166	0.004
3d alt	incinerator	166,068,810	1,777,836	13	23,111,868	2,158,894,530	8,047	225,307,696,046	52.6	187	123	9.15
3c alt	condenser	0	80,969	7	566,783		197	5,525,324,560	0.448	1.23	3.01	0.075
4d alt (HCl 80%)	incinerator/scrubber	131,310,794	979,978	1	979,978	131,310,794	341	9,553,385,531	2.86	10.5	5.24	0.500
4d alt (HCl 94%)	incinerator	131,310,794	942,842	5	4,714,210	656,553,970	1,641	45,956,812,914	14.2	51.9	25.2	2.47
4c alt (HCl 80%)	scrubber/condenser	0	205,895	0	0		0.000	0	0.000	0.000	0.000	0.000
4c alt (HCl 94%)	condenser	0	205,539	2	411,078		143	4,007,423,246	0.325	0.890	2.18	0.055
4sd alt (HCl only)	scrubber	0	37,136	1	37,136		12.9	362,022,949	0.029	0.080	0.197	0.005
1c alt	condenser	0	378,417	6	2,270,502		791	22,134,150,926	1.79	4.92	12.1	0.301
2d alt (HCl 80%)	incinerator/scrubber	13,892,987	108,536	2	217,072	27,785,974	75.6	2,116,141,897	0.613	2.24	1.16	0.107
2d alt (HCl 94%)	incinerator	13,892,987	104,434	1	104,434	13,892,987	36.4	1,018,082,309	0.303	1.11	0.558	0.053
2c alt (HCl 80%)	scrubber/condenser	0	31,345	1	31,345		10.9	305,568,971	0.025	0.068	0.166	0.004
2c alt (HCl 94%)	condenser	0	31,277	5	156,385		54.4	1,524,530,343	0.124	0.339	0.831	0.021
3c alt	condenser	0	80,969	1	80,969		28.2	789,332,080	0.064	0.175	0.430	0.011
4d alt (HCl 80%)	incinerator/scrubber	131,310,794	979,978	2	1,959,956	262,621,588	682	19,106,771,063	5.72	20.9	10.5	1.00
4d alt (HCl 94%)	incinerator	131,310,794	942,842	3	2,828,526	393,932,382	985	27,574,087,749	8.50	31.2	15.1	1.48
4d alt (HCl 80%)	scrubber/condenser	0	205,895	1	205,895		71.7	2,007,182,114	0.163	0.446	1.09	0.027
4d alt (HCl 94%)	condenser	0	205,539	1	205,539		71.6	2,003,711,623	0.162	0.445	1.09	0.027
			TOTAL:		55,980,000	4,198,000,000			111	388	298	19.3

(a) The HCl efficiency in parentheses is the baseline level of control for each model.

PAI NESHAP FILE: F:\PROJECT\AGCHEMS\ENV_IMP\ENV_IMP.XLS
Storage Tanks Environmental Impacts
01-May-97

Data:

Model	Control device	Electricity Kw-hr/yr per model	Number of models	Nationwide electricity, Kw-hr/yr	Coal burned to generate electricity, ton/yr	Coal burned to generate electricity, Btu/yr	w/ AP-42 EF kg CO/yr	w/ AP-42 EF kg NOx/yr	Controlled kg SO2/yr	Controlled kg PM/yr
MACT floor										
Model 1B (41 PERCENT)	condenser	5.66	35	198	0.0689	1,929,500	0.16	0.43	1.89	0.03
Model 2B (41 PERCENT)	IFR	0	8	0	0.0000	0	0.00	0.00	0.00	0.00
Model 3B (41 PERCENT)	IFR	0	16	0	0.0000	0	0.00	0.00	0.00	0.00
		TOTAL (Kw):		198		TOTAL (kg):	0.16	0.43	1.89	0.03
		TOTAL (Mw):		0.20		TOTAL (Mg):	0.000156	0.000429	0.001892	0.000026
Regulatory alternative 1										
Model 1B (41 PERCENT)	condenser	5.66	35	198	0.0689	1,929,500	0.16	0.43	1.89	0.03
Model 2B (95 PERCENT)	IFR	0	8	0	0.0000	0	0.00	0.00	0.00	0.00
Model 3B (95 PERCENT)	IFR	0	16	0	0.0000	0	0.00	0.00	0.00	0.00
		TOTAL (Kw):		198		TOTAL (KG):	0.16	0.43	1.89	0.03
		TOTAL (Mw):		0.20		TOTAL(MG):	0.00016	0.00043	0.00189	0.00003

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Wastewater Environmental Impacts

30-Apr-97

Nationwide WW flow			Density H2O (lb/gal):	8.33	
Total gallons ww/yr:	148,000,000		hours/year:	8,760	
L/V:	10				
Total Mg HAP controlled:	935.00				
Total gallons ww/yr:	0				
L/V:	0				
Total Mg HAP controlled:	1,517.34				
Reflux Ratio (L/D):	5				
Total quantity of H2O					
(ww + reflux):	148,000,000				
Impacts:					
Electricity required to run strippers, kw-hr/yr					
(if biotreatment considered):	88,503				
(if biotreatment not considered):	88,503				
Energy required to generate electricity (Btu/yr)					
(if biotreatment considered):	863,026,894				
(if biotreatment not considered):	863,026,894				
Electricity (Kw-hr/yr)			pump efficiency:	64.00%	
(if biotreatment considered):	252,865		hp:	0.7457	Kw
(if biotreatment not considered):	252,865		Kw-hr:	3,413	Btu
			ft H2O:	122	
			power plant efficiency:	35.00%	
			hp-s/ft-lbf	0.00182	
Actual Steam used (lb/yr)					
(if biotreatment considered):	118,542,308				
(if biotreatment not considered):	118,542,308				
Energy required to generate steam (Btu/yr)			steam (Btu/lb):	1180	
(if biotreatment considered):	174,849,903,846		boiler efficiency:	80.00%	
(if biotreatment not considered):	174,849,903,846		scf nat. gas	1,000	Btu
			lbmole nat. gas	392	
Solid Waste (Mg/yr)			lbmole CH4	0.004	lbmole CO
(if biotreatment considered):	935	(0 if returned to process)	lbmole CH4	0.001	lbmole NOx
(if biotreatment not considered):	935	(0 if returned to process)			
	Uncontrolled	Controlled			
Mg CO/yr			CO emission factor (lb/ton coal):	5	
(if biotreatment considered):	2.85		CO emission factor (lb/10^6 ft3 nat gas):		35
(if biotreatment not considered):	2.85		Btu/lb coal:	14,000	
			lb CO/lbmole CO	28	
Mg NOx/yr			NOx emission factor (lb/ton coal):	13.7	
(if biotreatment considered):	11.31		NOx emission factor (lb/10^6 ft3 nat gas):	140	
(if biotreatment not considered):	11.31		lb NOx/lbmole NOx	46	
Mg PM-10/yr			PM-10 unc. emission factor (lb/ton coal):	13.2	
(if biotreatment considered):	0.18	0.012	PM cont. emission factor (lb/ton coal):	0.84	
(if biotreatment not considered):	0.18	0.012			
Mg SO2/yr			SO2 unc. emission factor (lb * %S/ton coal):	38	
(if biotreatment considered):	0.96	0.85	SO2 cont. emission factor:	33.6	
(if biotreatment not considered):	0.96	0.85	% Sulfur:	1.80	

MRI

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Date: April 30, 1997

Subject: Cost Impacts of Regulatory Alternatives for the PAI Production NESHAP
EPA Contract 68D60012; Work Assignment No. 004
ESD Project No. 93/59; MRI Project No. 4800-04

From: Karen L. Schmidtke
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To: Lalit Banker
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I. Introduction

This memorandum presents the estimated cost and cost effectiveness of techniques to control missions from the five emission source types in the pesticide active ingredient (PAI) industry. The five emission source types are process vents, storage tanks, equipment leaks, wastewater, and bag dumps and product dryers. Costs were estimated for techniques likely to be used to control emissions to the maximum achievable control technology (MACT) floor control level and, for some emission source types, to the control level for one or two regulatory alternatives.

The MACT floor and regulatory alternatives for existing and new source process vents, equipment leaks, storage tanks, wastewater, and bag dumps and product dryers are provided in the MACT Floor and Regulatory Alternatives memorandum.[1] In addition, the baseline emissions and the hazardous air pollutant (HAP) emission reductions achieved by the standards are provided in the Baseline Emissions memorandum and the Environmental Impacts memorandum, respectively.[2,3]

Costs were developed for a variety of control techniques. For process vents, costs were developed for three types of add-on control devices (incinerators, condensers, and gas absorbers). For storage tanks, costs were developed for condensers and internal floating roofs (IFR). For wastewater, costs were developed for steam strippers an offsite disposal as a hazardous waste. For equipment leaks, costs were developed for implementation of a leak detection and repair (LDAR) program. No costs were developed for bag dump and product dryer controls because no model plants were developed.

This memorandum contains four sections. Section II presents a discussion of the cost analysis for each of the emission source types for existing sources. Section III presents the cost analysis for each emission source type for new sources. Section IV provides references.

II. Description of Cost Analysis for Existing Sources

A. Standard/Common Costs

Each of the cost analysis discussions in paragraphs B through F below includes specific information that details the assumptions and methodology used in costing control devices for each emission source type. Some of the assumptions are common to each cost analysis and are summarized in this paragraph.

In estimating the total capital investment (TCI) for control device equipment, the equipment costs were based on data from various years and must be scaled to represent cost in the current year. All equipment costs were scaled to June 1995 dollars. Purchased equipment costs (PEC) generally include the control device and auxiliary equipment costs, instrumentation costs, sales tax, and freight costs. Costs for instrumentation (10 percent), sales tax (3 percent), and freight (5 percent) were estimated to be 18 percent of control device and auxiliary equipment costs.

Several components of the annual costs are common for the control devices. These common costs include direct annual costs such as labor wages and maintenance costs, utilities, raw materials, and waste treatment. Common costs for indirect annual costs include overhead, administrative charges, property taxes, insurance, and capital recovery factors. These are listed in Table 1. Control equipment was assumed to operate 8,760 hours per year (hr/yr) for storage tanks and batch processes and 5,000 hr/yr for continuous processes.

B. Process Vents at Existing Sources

Emission control costs were developed for the MACT floor and two regulatory alternatives more stringent than the MACT floor.[1] For this analysis, the estimated 167 processes in the industry with uncontrolled emissions equal to or greater than the regulatory applicability cutoffs were each characterized with one of eight model processes. Eight model processes were developed to represent the industry: four with diluted emission streams and four with concentrated emission streams.[4] Control device costs for process vents were developed for three control devices: incinerators, condensers, and water scrubbers.

The MACT floor cost and cost effectiveness for each model process are shown in Attachment A. For the MACT floor, control device costs for diluted emission streams containing organic HAP

TABLE 1. COMMON ASSUMPTIONS FOR ANNUAL COST CALCULATIONS

Parameter/Factor	
Direct Annual Costs	
Operator labor wage rate (except steam stripper)	\$15.64 per hour
Operator labor wage rate (steam stripper)	\$22.50 per hour
Maintenance labor wage rate	\$17.21 per hour
Supervisor labor cost	15 percent of Operator labor cost
Maintenance materials cost	100 percent of Maintenance labor cost
Operator labor time requirements	0.5 hours per 8 hours operation
Maintenance labor time requirements	0.5 hours per 8 hours operation
Utilities	
Electricity	\$0.059 per kW-hr
Water	\$0.20 per 1,000 gallons
Natural gas	\$3.30 per 1,000 scf
Caustic	\$300 per ton
Wastewater treatment	\$3.80 per 1,000 gallons
Indirect Annual Costs	
Overhead	60 percent of all labor and maintenance material costs
Administrative, Property taxes, and Insurance	4 percent of TCI
Capital recovery factor for IFR, Incinerators, Manifolds, Condensers, Equipment leak components, and Initial LDAR labor	10-year equipment life at 7 percent interest rate (CRF = 0.1424)
Capital recovery factor for Scrubbers and Steam strippers	15-year equipment life at 7 percent interest rate (CRF = 0.1098)
Capital recovery factor for Equipment leaks monitoring instrument	6-year equipment life at 7 percent interest rate (CRF = 0.21)
Capital recovery factor for Equipment leaks rupture seals and pump seals	2-year equipment life at 7 percent interest rate (CRF = 0.55)

were based on incinerators, and costs for concentrated emission streams with organic HAP were based on condensers. Condenser costs were based on condensers that achieve a 90 percent control level for organic HAP; the organic HAP emission reduction achieved by the condenser control device is also based on the floor control level of 90 percent. While the floor requires organic HAP control of 90 percent, the incinerator costs were developed based on incinerators that achieve 98 percent control efficiency and the organic HAP emission reduction achieved by the control device was based on the 98 percent reduction.

The MACT floor requires 94 percent reduction of hydrogen chloride (HCl) emissions. Costs for a water scrubber to control HCl emissions were developed for process vent models 2D, 2C, 4D, and 4C. While the floor requires 94 percent reduction of HCl emissions, the scrubber costs were developed for a device that achieves 99 percent control efficiency, and the emission reduction achieved by the device was based on 99 percent control.

The cost and cost effectiveness for the regulatory alternatives are shown in Attachment A. Twenty-three of the streams represented by models 1C, 2D, 2C, 3C, 4C, and 4D are subject to more stringent control levels for organic HAP under Regulatory Alternative 1, and the costs to control these streams are provided in the Attachment. For Regulatory Alternative 1, the cost to control models with incinerators is equivalent to the cost estimated for the floor. The cost to control models with condensers is equivalent to the floor costs for all models except those subject to more stringent control requirements for organic HAP; the incremental increase in cost for these models is due to the increase in control efficiency required by the device. Regulatory Alternative 1 costs for scrubbers to control HCl emissions are identical to floor costs.

Regulatory Alternative 2 requires more stringent control than the floor for both organic HAP and HCl emissions. The cost and cost effectiveness data for Regulatory Alternative 2 are provided in Attachment A for each model. The cost to control models with incinerators is equivalent to the cost for both the floor and Regulatory Alternative 1. There is an incremental increase in cost for 49 streams represented by models controlled with condensers and that are subject to a more stringent control requirement for Regulatory Alternative 2 than Regulatory Alternative 1 (models 1C, 2C, 3C, and 4C). The cost for 99 percent emission reduction of HCl required by Regulatory Alternative 2 is equivalent to the cost estimated for the floor and Regulatory Alternative 1.

The nationwide costs and actual cost effectiveness of the MACT floor and regulatory alternatives are shown in Table 2. The incremental cost effectiveness for requiring control levels above the stringency of the MACT floor and the incremental cost effectiveness between the regulatory alternatives are also

TABLE 2. PROCESS VENT MACT FLOOR AND REGULATORY ALTERNATIVES NATIONWIDE COSTS FOR EXISTING SOURCES[a]

Option	Uncontrolled emissions, Mg/yr	Baseline emissions, Mg/yr	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness relative to baseline, $/Mg	Incremental cost effectiveness, $/Mg
MACT floor	16,520	1,996	55,710,000	33,780,000	1,236	62	27,320	
								2,900
Regulatory Alternative No. 1	16,520	1,996	56,220,000	33,910,000	1,281	64	26,460	
								14,000
Regulatory Alternative No. 2	16,520	1,996	59,390,000	35,220,000	1,375	69	25,600	

[a] The emissions and costs in this analysis are based on the use of model processes to represent all processes in the industry, including processes at the surveyed facilities.

provided. The cost effectiveness (from baseline) for Regulatory Alternatives 1 and 2 are $26,500 per megagram (/Mg) and $25,600/Mg, respectively. The incremental cost effectiveness from the floor to Regulatory Alternative 1 is $2,900/Mg, and the incremental cost effectiveness from Regulatory Alternative 1 to 2 is $14,000/Mg.

Example design and cost algorithms for the three control devices are presented in Attachment A. The assumptions and data used in each algorithm are described below.

1. Condenser. The refrigeration unit size (tons of cooling) is based on an energy balance around the unit when the process is venting and the inlet stream contains its maximum HAP load. Costs were developed for packaged, multiple-stage refrigeration units using the approach in the Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual.[5] This approach estimates that the refrigeration unit cost is 80 percent of the refrigeration system equipment cost. The remaining 20 percent of the system cost includes the HAP condenser, recovery tank, connections, piping, and instrumentation.

The PEC for the refrigeration system is equal to the total equipment cost plus 8 percent for sales tax and freight. The installation cost for the refrigeration system is equal to the PEC for the system plus 15 percent.

The manifolding equipment cost was estimated for venting one process with a total of 6 vents to the condenser. The number of vents per process was based on the average from the surveyed plants.[4] The manifold equipment cost includes the cost of one automatic damper, 300 feet of duct designed to convey exhaust gas at 2,000 feet per minute, twelve elbows, and six detonation arrestors. The PEC for the manifold is equal to the manifold equipment cost plus 18 percent for instrumentation, taxes and freight. The installation cost for the manifold is assumed to be equal to the PEC for the manifold.

The cost to conduct an initial compliance test to demonstrate the efficiency of the condenser is estimated to be $24,420.[6] The cost for a thermocouple and datalogger to monitor the exit stream temperature from the condenser is estimated to be $3,000.[6]

The TCI is equal to the sum of the PEC for the refrigeration system, PEC for the manifold, installation cost of the refrigeration system, installation cost of the manifold, cost for the performance test, and cost for a thermocouple and datalogger.

The total annual cost (TAC) for the condenser consists of direct annual costs and indirect annual costs. Direct annual costs are costs for labor, maintenance materials, and utilities (electricity). Indirect annual costs are costs for overhead, administrative charges, property taxes, insurance, and capital recovery. Except for electricity requirements, the unit costs and other factors used to estimate these costs are given in Table 1.

Electricity requirements for the refrigeration unit were estimated using the tabulated data in the OAQPS Control Cost Manual.[5] Linear regression was used to develop an equation for electricity requirements per ton of cooling as a function of the condenser temperature. The mechanical efficiency of the compressor was estimated to be 85 percent. Electricity requirements for pumps and blowers were considered to be negligible relative to the requirements for the refrigeration unit.[5]

2. Incinerator. Costs for thermal incineration units were calculated for packaged, recuperative incinerators based on the approach in the OAQPS Control Cost Manual.[7] The cost of the incineration unit is based on the volumetric flowrate of flue gas exiting the unit. The incinerator unit costs are based on the assumption that 70 percent of the energy from the incinerator flue gas is recovered. The incinerator unit cost includes auxiliary equipment, which includes the stack and collection fan.

The PEC for the incinerator is equal to the total equipment cost for the incinerator unit and auxiliary equipment plus sales tax and freight.

Direct installation cost for the incinerator unit and auxiliary equipment is equal to 30 percent of the incinerator PEC. These costs are for foundations and supports, handling and erection, electrical installation, piping installation, insulation for ductwork, and painting. Indirect installation costs include engineering, construction and field expenses, contractor fees, startup, performance test, and contingencies. The indirect installation cost is equal to 31 percent of the incinerator PEC.

The cost to conduct an initial compliance test to demonstrate the efficiency of the incinerator is estimated to be \$24,420.[6] The cost for a thermocouple and datalogger to monitor the exit chamber temperature from the incinerator is estimated to be \$3,000.[6]

The manifold equipment cost was estimated using the same method that was used for condensers for process vents.

The TCI is equal to the sum of the PEC for the incinerator plus the direct and indirect installation costs and the sum of the PEC and the installation cost for the manifolding. The compliance test and monitoring equipment costs are initial costs that were also considered to be part of the TCI.

The TAC consists of direct annual costs and indirect annual costs. Direct annual costs are costs for labor, maintenance materials, and utilities (natural gas and electricity). Indirect annual costs are costs for overhead, administrative charges, property taxes, insurance, and capital recovery. Except for natural gas and electricity requirements, the unit costs and other factors used to estimate these costs are given in Table 1.

Natural gas requirements are based on the amount of auxiliary fuel necessary to stabilize the incinerator flame and to maintain the incinerator temperature. Auxiliary fuel requirements are at a maximum when the process is not venting to the incinerator; depending on the organic concentration in the exhaust stream, the auxiliary fuel requirements may be significantly less when the process is venting. The equations to calculate the amount of auxiliary fuel are described in the OAQPS Control Cost Manual.[7]

Electricity requirements were also estimated using equations in the OAQPS Control Cost Manual.[7] Electricity requirements were estimated for the fan and motor; the estimate is based on the volumetric flowrate, pressure drop, and the combined mechanical efficiency of the fan and motor. The mechanical efficiency is estimated to be 60 percent.

3. Scrubber. The total equipment cost for the scrubber system is equal to the sum of the tower cost plus auxiliary equipment such as packing material and a pump. The scrubber tower cost is based on the surface area of the unit. Costs were developed using the approach in the OAQPS Control Cost Manual for packed tower absorbers made of fiberglass reinforced plastic.[8] The equipment cost for the scrubber tower includes the tower shell and numerous equipment components associated with the tower. The equipment cost of the packing material is based on use of ceramic Raschig rings at $20 per cubic foot. The equipment cost of the pump used for circulating water is based on a cost of $16 per gallon per minute of scrubber water.

The PEC for the scrubber system is equal to the total equipment cost plus 10 percent for instrumentation and controls and 8 percent for sales tax and freight.

The TCI is equal to the PEC for the scrubber system plus the direct and indirect installation costs. The direct installation costs are equal to 85 percent of the PEC and include foundations and supports, handling and erection, electrical, piping, insulation, and painting. Indirect installation costs include engineering, construction and field expenses, contractor fees, startup, performance test, and contingencies and are equal to 35 percent of the PEC.

The TAC for the scrubber system consists of direct annual costs and indirect annual costs. Direct annual costs are costs for labor, maintenance materials, utilities (electricity and water), purchase of caustic, and wastewater treatment. Indirect annual costs are costs for overhead, administrative charges, property taxes, insurance, and capital recovery. Except for electricity and water requirements, the unit costs and other factors used to estimate these costs are given in Table 1.

Electricity requirements for the scrubber unit were estimated using equations in the OAQPS Control Cost Manual.[8] Electricity requirements were estimated for the pump. The mechanical efficiency of the pump is estimated to be 70 percent. The annual amount of water usage was based on the liquid flowrate necessary for operation of the scrubber plus makeup water. The annual caustic usage was estimated based on the stoichiometric amount necessary to neutralize the HCl.

C. <u>Storage Tanks at Existing Sources</u>

For the cost analysis, the 238 storage tanks in the industry were each characterized by a model tank. A total of nine model storage tanks were developed to represent the industry.[4] Emission control device costs were calculated for the MACT floor and one regulatory alternative more stringent than the floor.

The MACT floor control costs were developed for two control devices: IFR and condensers. Condensers were costed for control of storage tanks with capacity less than 76 cubic meters (m^3) (20,000 gallons); IFR were costed for storage tanks greater than 76 m^3 (20,000 gallons). Costs for IFR were used for tanks greater than 76 m^3 (20,000 gallons) because the IFR costs are less than condenser costs; it was assumed that facilities would install the least costly control device that meets the control requirements. Costs were developed for only three of the model storage tanks. Models 1B, 2B, and 3B are the only models that meet the MACT floor applicability criteria and are not already controlled to greater than or equal to 41 percent. The floor requires HAP emission control of 41 percent, but the IFR achieves emission reductions of 95 percent and the emission reduction was based on the 95 percent control efficiency. Condenser costs and emission reductions were based on condensers that achieve the floor control level. The costs and cost effectiveness for control devices for each model tank are shown in Attachment B.

The regulatory alternative control costs were also developed for IFR and condensers. The resulting costs and cost effectiveness are shown in Attachment B for each model. The regulatory alternative requires more stringent control of storage tank emissions for tanks greater than or equal to 76 m^3 (20,000 gallons) (models 2B and 3B). There is no increase in cost or emission reduction from the floor to the regulatory alternative with use of IFR control. There is no change in the requirements for storage tanks less than 76 m^3 (20,000 gallons) for the regulatory alternative and therefore, no change in the cost or emission reduction (model 1B).

As shown in the regulatory alternative table in Attachment B, there is no incremental cost effectiveness for models 2B and 3B. As noted above, the emission reduction achieved by the IFR for these models is the same under Regulatory Alterative 1 and the MACT floor. Therefore, the cost for the regulatory alternative is equivalent to the cost to meet the MACT floor.

The nationwide costs and cost effectiveness of the MACT floor and regulatory alternative are shown in Table 3, along with the nationwide incremental cost effectiveness for the regulatory alternative above the floor.

A cost algorithm table for the IFR control devices is presented in Attachment B; the condenser cost algorithm is similar to the one shown in Attachment A for process vents. The assumptions and data used in each algorithm is described below.

1. IFR. The cost of an IFR was based on an aluminum noncontact IFR with vapor-mounted primary seal and secondary seal.[9] The installed capital costs were based on an equation relating cost of the floating roof to the diameter of the storage tank. Initial costs for degassing and cleaning ($150 per foot of diameter) and sludge disposal (assume 1 percent sludge volume at $5 per gallon disposal cost) were also estimated. Annual costs were developed for capital recovery, taxes, insurance, administration, and operating costs (6 percent of installed capital and other initial costs).

2. Condenser. The estimated condenser costs for storage tanks were developed following the same methodology used to estimate the cost of condensers for process vents. The refrigeration unit size (tons of cooling) is based on an energy balance around the unit when the inlet stream contains its maximum HAP load. Maximum HAP load occurs while filling the tank (i.e., working losses). Just as for the process vent condensers, costs were developed for packaged, multiple-stage refrigeration units using the approach in the OAQPS Control Cost Manual.[5] The remainder of the approach is also similar, with only a few differences detailed below.

No manifolding equipment costs were estimated for control of storage tanks with condensers. Unlike process vents where multiple vents are manifolded to the control device, the storage tank has only one vent. In addition, each storage tank was assumed to be controlled with a condenser in close proximity to the tank.

TABLE 3. STORAGE TANK MACT FLOOR AND REGULATORY ALTERNATIVES NATIONWIDE COSTS FOR EXISTING SOURCES

Option	No. of tanks controlled nationwide	Uncontrolled emissions, Mg/yr	Baseline emissions, Mg/yr	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness from baseline, $/Mg	Incremental cost effectiveness, $/Mg
MACT Floor	57	219.4	37.31	866,900	607,400	19.98	54	30,410	
									0.0
Regulatory Alternative No. 1	57	219.4	37.31	866,900	607,400	19.98	54	30,410	

The direct annual cost, which is part of the total annual costs, were estimated for full-time operation because this analysis assumes storage tank condensers will be in service for 8,760 hr/yr.

In estimating the annual cooling load, and thus the electricity requirements, separate loads were estimated for the time periods when working losses are vented to the condenser and when breathing losses are vented to the condenser. The load during breathing losses is significantly lower than during working losses. The inputs to the condenser cost algorithm are shown in Attachment B.

D. Wastewater at Existing Sources

Emission control costs for wastewater were developed for the MACT floor and one regulatory alternative. The MACT floor is no control, and the regulatory alternative consists of a variety of control requirements that can be met using one of several control techniques.[1] Cost impacts for the regulatory alternative were estimated assuming that all facilities use either a steam stripper to remove HAP from wastewater, or they dispose of wastewater as a hazardous waste (which is treated by incineration). Costs were developed for 22 model wastewater streams representing a total of 30 wastewater streams nationwide; the selection of these streams is described in the Model Plants memorandum.[4]

The total nationwide capital and annual costs, the emission reduction achieved, and the cost effectiveness of the MACT floor and the regulatory alternative are presented in Table 4. There are no cost impacts associated with the MACT floor because the floor is no control. For the regulatory alternative, it was assumed that facilities would use the least costly control technique. Steam stripping was the least costly technique for 21 of the 30 wastewater streams, and hazardous waste disposal was the least costly for the other 9 wastewater streams. The cost-effectiveness values for individual streams range from $430/Mg to $122,000/Mg, and the nationwide average incremental cost effectiveness of the regulatory alternative is $3,070/Mg.

The estimated capital and annual costs of the control techniques under the regulatory alternative for each of the 22 model wastewater streams, the emission reduction achieved per model, the characteristics of each model, and the nationwide population of each model are provided in Attachment C. An example cost algorithm for steam strippers and example hazardous waste cost calculations are also included in Attachment C. The assumptions and data used to calculate the steam stripper and hazardous waste disposal costs are described below.

1. Steam stripper system. Costs for steam stripper systems are based on the approach used for the Hazardous Organic

TABLE 4. WASTEWATER MACT FLOOR AND REGULATORY ALTERNATIVES NATIONWIDE COSTS FOR EXISTING SOURCES

Option	Uncontrolled emissions, Mg/yr[a]	Baseline emissions, Mg/yr[b]	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness from baseline, $/Mg	Incremental cost effectiveness, $/Mg
MACT floor	2,490	1,530	0	0	0.0	0.0	0	
								3,070
Regulatory Alternative	2,490	1,530	9,777,000	2,869,000	934	61	3,070	

[a]The uncontrolled emissions consist of 1,340 Mg/yr from streams subject to the regulatory applicability criteria and 1,150 Mg/yr from other streams.

[b]The baseline emissions consist of 1,340 Mg/yr from streams subject to the regulatory applicability criteria and 190 Mg/yr from other streams.

NESHAP (HON) wastewater control cost analysis.[10] The steam strippers were designed to achieve the fraction removed (Fr) value for the HAP in the wastewater stream. In estimating the size of the steam stripper, it was assumed that the wastewater flow rate would be equal to the annual flow rate divided by the annual steam stripper operating hours. The operating hours of the steam stripper were estimated to be 85 percent of the process operating hours. The minimum treatment rate was assumed to be 5 gallons per minute (for instances where annual flow rate divided by operating hours was less than 5 gallons per minute). The liquid to vapor ratio was 10.4 pounds of wastewater per pounds of steam, and the number of theoretical trays was assumed to be 5. The steam was at 100 pounds per square inch, gauge (psig) and 350°F. The column flooding rate was assumed to be 80 percent. The wastewater stream enters the feed preheater at 68°F and enters the stripper column at 170°F.

The total equipment cost for the steam stripper system is equal to the sum of the steam stripper column cost plus the cost for auxiliary equipment, which includes the wastewater feed tank, the wastewater preheater, overheads condenser, overheads decanter, pumps, and a flame arrestor. As in the HON wastewater cost analysis, the steam stripper column equipment cost was estimated using the average from two costing approaches. One costing scenario estimated the cost for the column shell, skirt, nozzles, manholes, platform, ladder, and trays, and the other costing scenario estimated the cost for the column shell, manholes, nozzles, trays, platform, ladder, handrail, and insulation costs.[10]

The equipment cost for the feed tank and the overheads decanter were both estimated based on equations relating tank capacity to cost. The equipment cost of the overheads condenser was based on an equation relating the condenser surface area to cost. Equipment cost for four pumps was estimated from cost equations relating horsepower and cost. The feed preheater equipment cost was estimated from an equation relating flow rate and cost. The flame arrestor equipment cost was estimated to be $100.[10]

The PEC for the steam stripper system is equal to the total equipment cost plus the cost for piping, instrumentation, sales tax, and freight. Piping cost and instrumentation cost was estimated to be equal to 30 percent and 10 percent, respectively, of the equipment cost. Sales tax and freight are equal to 8 percent of the cost for the total equipment, piping, and instrumentation.

The TCI for all stripper system equipment is equal to the sum of the PEC for the system and the direct and indirect installation costs. The direct installation costs are equal to 55 percent of the PEC and include foundation and support, electrical, erection and handling, painting, and insulation costs.[10] Indirect installation costs include engineering and supervision, construction and field expenses, startup and testing, and contingency costs and are equal to 35 percent of the PEC.[10]

The TAC consists of direct and indirect annual costs. Direct annual costs are costs for labor, maintenance, and utilities (steam, electricity, and water). Indirect annual costs are costs for overhead, administrative charges, property taxes, insurance, and capital recovery.

2. Hazardous waste disposal costs. The cost for hazardous waste disposal was based on a unit cost per gallon of wastewater sent for disposal. Cost for disposal were $0.704 per gallon of wastewater (or $169.02 per ton of wastewater).[11] There are no capital costs associated with hazardous waste disposal of wastewater.

E. Equipment Leaks at Existing Sources

Control costs for equipment leaks were estimated for the MACT floor and one regulatory alternative. For determining the cost of the regulatory alternative, the costs to control equipment leak emissions were estimated for 28 of the surveyed processes based on actual equipment component counts, operating hours, and estimated control efficiencies for reported LDAR programs. The control cost estimates for the 175 modelled processes are based on a batch equipment leak model and a continuous equipment leak model; there is no baseline LDAR program for the models.

The regulatory alternative control costs for equipment leak emissions are based on the LDAR program of 40 CFR part 63, subpart H. A cost algorithm similar to the one used to estimate control costs for subpart H of the HON was used to estimate costs for the PAI industry.[12] An example cost algorithm for the batch equipment leak model is presented in Attachment D. The assumptions and data used in the cost algorithm are described below.

The control costs for a LDAR program include capital costs (equipment costs), indirect annual costs (annualized equipment costs and annualized initial monitoring and repair charges), and direct annual costs (maintenance, miscellaneous, and labor charges).

Equipment costs for each surveyed process and model process were developed for the monitoring instrument and various parts used to control emissions. These parts were estimated to cost $434 for sample connections and $4,176 for pressure relief devices. The monitoring instrument costs $6,907. The total equipment cost per model or process is equal to the sum of the equipment cost for all components.

The TCC is equal to the sum of the equipment cost for each component type.

The cost for the initial monitoring of liquid valves, gas valves, pumps, and connectors is based on the component count, a monitoring cost of $2.50 per component, plus 40 percent for administrative charges. The cost for the initial repair is based on the component count, the initial leak frequency (percentage), the fraction of components that require repair, the hours required for each repair, a repair labor cost of $22.50 per hour, plus 40 percent for administrative and support charges. An additional repair cost for pumps was included for replacement seals; this replacement cost is based on the number of pumps, the initial leak frequency (percentage), the fraction of pumps requiring repair, and a $191.30 replacement cost for the seal. The initial leak frequency, the fraction requiring repair, and the hours for repair are provided in Table 5.

TABLE 5. PARAMETERS USED TO CALCULATE INITIAL AND ANNUAL MONITORING AND REPAIR LABOR COSTS

Parameter	Gas valves	Light liquid valves	Pumps	Sampling connections	Pressure relief devices
Initial leak frequency, %	11.4	6.5	20.0	2.1	N/A
Subsequent leak frequency, %	2.0	2.0	10.0	0.5	N/A
Fraction requiring repair	0.25	0.25	0.75	0.25	N/A
Hours for repair per component	4	4	16	2	N/A
Monitoring frequency	Quarterly	Quarterly	Monthly[a]	Annually	Annually

[a]Weekly visual monitoring is also conducted for pumps.

The indirect annual costs consist of miscellaneous charges and capital recovery. Miscellaneous charges for monitoring instruments, pressure relief devices, and sampling connections are equal to 4 percent of the equipment cost. The annual miscellaneous charges include taxes, insurance, administration, and other fees. Miscellaneous charges for replacing pump seals is equal to 80 percent of the maintenance charge for the pump seals. The total equipment cost and the cost for the initial monitoring and repair were annualized using capital recovery factors. The capital recovery cost for the equipment is based on the capital equipment cost and the appropriate capital recovery factors for the individual components (see Table 1). The annualized cost for the initial monitoring of liquid valves, gas valves, pumps, and connectors is based on the cost for initial monitoring of each component and the appropriate capital recovery factor for that component. The annualized cost for the initial repair is based on the initial cost to repair each component and the appropriate capital recovery factor for each component type. An additional capital recovery cost for repair of pumps is included for replacement seals.

The direct annual costs associated with the LDAR program include annual maintenance charges, annual miscellaneous charges, and annual labor charges. The maintenance cost for the monitoring device is $4,548. The maintenance cost for pressure relief devices, and sampling connections is equal to 5 percent of the equipment cost. The maintenance charge for replacing pump seals is equal to $191 per pump repaired.

Annual labor charges for conducting the LDAR program are for monitoring and repairs. The annual labor cost associated with monitoring of gas valves, liquid valves, pumps, connectors, and pressure relief devices is based on the component count, the number of monitorings performed per year, a monitoring fee of $2 per component, plus 40 percent for administrative and support costs. Labor costs for monitoring of pumps also includes the cost for visual monitoring of the pump each week; this cost is based on the number of pumps, weekly monitorings, 30 seconds of monitoring time per pump, the monitoring labor cost of $22.50 per hour, plus 40 percent for administrative and support costs. The annual labor cost for repairing equipment components is based on the component count, the leak frequency, the number of monitorings per year, the fraction of components requiring repair (percentage), the hours required per repair, the repair labor cost of $22.50 per hour, plus 40 percent for administrative and support. The leak frequency, fraction requiring repair, hours for repair, and the monitoring frequency are provided in Table 5.

The TAC is equal to the annualized equipment and annualized initial monitoring and repair costs, the annual maintenance charges, the annual miscellaneous charges, and the annual labor charges. A credit of $1,250/Mg of product recovered is included for materials that are no longer lost to equipment leaks.

The nationwide costs and cost effectiveness of the MACT floor and regulatory alternative are shown in Table 6. There are no cost impacts associated with the equipment leak MACT floor because the floor is no control. The average cost effectiveness for the regulatory alternative for the equipment leak emission source is $546/Mg, and the cost effectiveness for the individual models and processes range from a cost of $30,100/Mg to a savings of $722/Mg. The cost and cost effectiveness for each of the surveyed processes and each model process for the regulatory alternative are shown in Attachment D. The emissions reductions used in these cost-effectiveness calculations were developed in the Baseline Emissions and Environmental Impacts memoranda.[2,3]

TABLE 6. EQUIPMENT LEAK MACT FLOOR AND REGULATORY ALTERNATIVE NATIONWIDE COSTS FOR EXISTING SOURCES

Option	Uncontrolled emissions, Mg/yr	Baseline emissions, Mg/yr	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness from baseline, $/Mg	Incremental cost effectiveness, $/Mg
MACT floor	3,700	3,410	0	0	0.0	0.0	0	
								546
Regulatory Alternative	3,700	3,410	3,397,000	1,650,000	3,022	89	546	

F. Bag Dumps and Product Dryers at Existing Sources

No emission control device costs for controlling particulate HAP were developed for the existing source MACT floor. It is assumed that processes with particulate HAP emissions are already controlled to the floor level for existing sources, therefore, no additional control equipment is necessary.[1]

III. Description of Cost Analysis for New Sources

A. Number of Sources

Average annual growth rates in PAI sales in the 5 years after the standards are promulgated were estimated to be approximately 2 percent. The number of new sources manufacturing PAI is assumed to correlate to the increase in production and sales, thus an estimated eight new facilities will be subject to the standards.[13] It is assumed that the new facilities will have emissions points and control devices similar to the emission points and control devices at existing sources.

B. Process Vents at New Sources

Emission control costs were developed for the new source MACT floor. A total of 14 new processes are estimated for the 8 new facilities.[4] These new processes were modelled using the same model processes as for existing sources. Control costs for incinerators, condensers, and water scrubbers were developed using the same algorithms as for existing; emission reductions achieved by the devices were also estimated using the same assumptions as for existing sources (see sections II.A and B).

The MACT floor cost and cost effectiveness for each model process are shown in Attachment E. The nationwide cost and cost effectiveness for the process vent MACT floor for new sources are shown in Table 7. (See the design and cost algorithms presented in Attachment A. See section II.B for discussion of the assumptions and data used in each algorithm.)

C. Storage tanks at new sources

Emission control device costs were calculated for the new source MACT floor. A total of 6 storage tanks subject to the new source floor are estimated.[4] The new storage tanks were modelled using the existing source models. The MACT floor control costs and emission reductions were developed for IFR and condensers using the same cost algorithms and assumptions as for existing sources.

The costs and cost effectiveness for the MACT floor are shown in Attachment F for each new storage tank. The nationwide cost and cost effectiveness for storage tanks at new sources

TABLE 7. PROCESS VENT MACT FLOOR NATIONWIDE COSTS FOR NEW SOURCES

Option	Uncontrolled emissions, Mg/yr	Baseline emissions, Mg/yr	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness, $/Mg
MACT floor	1,572	286	7,771,000	4,619,000	265	93	17,580

subject to the MACT floor are provided in Table 8. (See the cost algorithm table in Attachment B for IFR and the condenser algorithm in Attachment A; see sections II.B and C for the condenser cost discussion and section II.C for IFR cost discussion.)

D. Wastewater at New Sources

Emission control costs were developed for the new source MACT floor and two regulatory alternatives. Based on the model plants analysis, five of the eight estimated new plants were assumed to have wastewater streams (two represented by model LFr, two represented by model HFr, and one represented by model HW).[4] None of these models exceeds the 2,100 megagrams per year (Mg/yr) applicability criteria for the MACT floor for new sources (Note: this result is believed to be reasonable because only one existing source is known to exceed the cutoff). Therefore, no control is needed to meet the MACT floor, and there are no cost impacts associated with the floor.

The control requirements under Regulatory Alternative 1 for new sources are the same as under the regulatory alternative for existing sources.[1] In addition, the distribution of wastewater streams at new sources is assumed to be the same as at existing sources, and the MACT floor in both cases is no control. Therefore, the average uncontrolled emissions, the average control costs, and the average cost effectiveness per stream under Regulatory Alternative 1 for new sources should be the same as under the regulatory alternative for existing sources. This result, however, cannot be obtained using the model wastewater streams because there are so few streams at new sources that the models cannot be distributed in the same ratio as at existing sources. Therefore, emission control costs for regulatory alternative 1 for new sources were estimated using data from the analysis for existing sources. As shown in Table 4, the TAC under the regulatory alternative for existing sources was $2.87 million. This value was divided by 30 (the number of streams at existing sources) to obtain the average cost per stream. This average value was then multiplied by 5 to estimate the nationwide TAC for streams at new sources. Similar calculations were used to estimate the emissions and emissions reductions for new sources. Thus, the cost effectiveness of Regulatory Alternative 1 for new sources is $3,070/Mg, the same as for existing sources. The nationwide cost and cost effectiveness for wastewater streams at new sources under Regulatory Alternative 1 are presented in Table 9.

Relative to Regulatory Alternative 1, the applicability requirements under Regulatory Alternative 2 consist of smaller flow rate cutoffs and lower HAP concentration cutoffs.[1] The models used in the analyses for existing sources were not based on streams with these characteristics. Therefore, the emission control cost analysis for Regulatory Alernative 2 was based on

TABLE 8. STORAGE TANK MACT FLOOR NATIONWIDE COSTS FOR NEW SOURCES

Option	No. of tanks controlled nationwide	Uncontrolled emissions, Mg/yr	Baseline emissions, Mg/yr	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness, $/Mg
MACT Floor	6	3.10	2.91	654,000	494,100	1.08	37	458,100

TABLE 9. WASTEWATER MACT FLOOR NATIONWIDE COSTS FOR NEW SOURCES

Option[a]	Uncontrolled emissions, Mg/yr	Baseline emissions, Mg/yr	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness, $/Mg	Incremental cost effectiveness, $/Mg
MACT floor[b]	0	0	0	0	0	0	0	
								3,070
Regulatory Alternative 1[c]	223.5	223.5	1,629,000	478,000	136.3	61	3,070	

[a]Regulatory Alternative 2 is not shown. See the discussion of the new source Regulatory Alternative 2 in the text.

[b]It is estimated that there are no wastewater streams that will be subject to the new source MACT floor. Therefore, there are no costs or emission reductions.

[c]The costs and emission reductions for Regulatory Alternative 1 are based on the average emissions and cost per stream for existing source wastewater streams. The emission reduction and percent reduction from baseline is equal to the percent reduction achieved for existing sources (61 percent). The cost effectiveness is also equal to the cost effectiveness for the existing source regulatory alternative.

information about the individual streams at the surveyed plants that would meet the more stringent applicability criteria. A total of 10 additional streams at the surveyed plants would meet the applicability criteria under Regulatory Alternative 2. Two of the streams are from processes that have other wastewater streams covered under Regulatory Alternative 1, and eight streams are from processes that have no streams covered under Regulatory Alternative 1. Characteristics of the 10 streams are presented in Attachment G. In the Model Plants analysis, nine of these streams were models that each represented two streams nationwide, and one represented three sreams. Just as in the analysis for Regulatory Alternative 1, the distribution of streams at existing and new sources is assumed to be the same. Therefore, the incremental cost-effectiveness of Regulatory Alternative 2 would be approximately equal to the overall incremental cost effectiveness for the 10 streams; the actual number of streams that would be subject to Regulatory Alternative 2 does not need to be estimated. The control costs were developed for steam strippers and disposal as a hazardous waste (with treatment by incineration). The results of the analyses are shown in Attachment G; the cost effectiveness values range from $3,290/Mg to $2.2 million/Mg for the individual streams, and the overall cost effectiveness is $226,000/Mg. Thus, even if the distribution of streams at new and existing sources differ, the incremental cost effectiveness of Regulatory Alternative 2 would be high. (See the cost algorithm for steam strippers in Attachment C. See section II.D for discussion of the steam stripper costs.)

E. Equipment Leaks at New Sources

Control costs for equipment leaks were estimated for the new source MACT floor. A total of 18 new processes subject to the new source MACT floor for equipment leaks have been estimated, and the equipment leak control cost is based on component count models of these 18 processes. Just as for existing sources, control costs are based on the LDAR program of 40 CFR part 63, subpart H.

The costs and cost effectiveness for each model process are shown in Attachment H. The nationwide cost and cost effectiveness for equipment leaks at new sources are shown in Table 10. (See the equipment leak cost algorithm in Attachment D. See section II.E for the discussion of equipment leak costs.)

F. Bag Dumps and Product Dryers at New Sources

No control device costs for controlling particulate HAP were developed. It is assumed that processes with particulate HAP emissions are already controlled to the new source floor level and there are no costs for additional control equipment.[1]

TABLE 10. EQUIPMENT LEAK MACT FLOOR NATIONWIDE COSTS FOR NEW SOURCES

Option	Uncontrolled emissions, Mg/yr	Baseline emissions, Mg/yr	Nationwide TCI, $	Nationwide TAC, $/yr	Emission reduction from baseline, Mg/yr	Emission reduction from baseline, %	Cost effectiveness, $/Mg
MACT floor	379	379	317,000	143,400	339	89	423

IV. REFERENCES

1. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 30, 1997. MACT Floor and Regulatory Alternatives for the Pesticide Active Ingredient Production Industry.

2. Memorandum from D. Randall, K. Schmidtke, and C. Hale, MRI, to L. Banker, EPA:ESD. April 30, 1997. Baseline Emissions for the Production of Pesticide Active Ingredient Industry.

3. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 30, 1997. Environmental Impacts for the Pesticide Active Ingredient Production NESHAP.

4. Memorandum from D. Randall and K. Schmidtke, MRI, to L. Banker, EPA:ESD. April 30, 1997. Model Plants for the Pesticide Active Ingredient Production Industry.

5. OAQPS Control Cost Manual. Fourth Edition. EPA 450/3-90-006. January 1990. Chapter 8. Refrigerated Condensers.

6. Memorandum from B. Shine, MRI, to R. McDonald, EPA:ESD. July 14, 1993. Enhanced Monitoring Costs for Polymers and Resins II NESHAP.

7. OAQPS Control Cost Manual. Fourth Edition. EPA 450/3-90-006. January 1990. Chapter 3. Thermal and Catalytic Incinerators.

8. OAQPS Control Cost Manual. Fourth Edition. EPA 450/3-90-006. January 1990. Chapter 9. Gas Absorbers.

9. Alternative Control Techniques Document: Volatile Organic Liquid Storage in Floating and Fixed Roof Tanks. EPA Publication No. EPA-453/R-94-001. January 1994. p. 6-29.

10. Memorandum from D. Whitt, Radian, to D. Markwordt, EPA:CPD. June 5, 1991. Impacts from the Control of Volatile Hazardous Air Pollutant Emissions from Equipment in Non-SOCMI Process Units for HON.

11. Engineering Cost Model Documentation Report for the Pharmaceutical Manufacturing Industry. Prepared by Radian Corporation for U. S. Environmental Protection Agency, Office of Water. February 28, 1995. pp. 2-8 and 4-29.

12. Memorandum from K. Scott, Radian, to M. Kissell, EPA. June 30, 1993. Steam Stripper Total Capital Investment and Total Annual Costs.

13. Memorandum from K. Schmidtke, MRI, to L. Banker, EPA:ESD. January 6, 1997. Growth Projections for the Pesticide Active Ingredient Production Industry.

ATTACHMENT A

- Costs and Cost Effectiveness Tables for the Process Vent MACT Floor and Regulatory Alternatives for Existing Sources
- Example Condenser, Incinerator, and Scrubber Cost Algorithms for Process Vent Models 2d and 2c

MACT FLOOR COSTS, EMISSION REDUCTIONS, AND COST EFFECTIVENESS FOR PROCESS VENTS (OVERALL)
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\DATADDR\PVCOSTEF.XLS

Model	HAP content (a)	Number of models: modelled plants (b)	Number of models: surveyed plants (c)	Number of models: Total	Control device (d)	TCI per model, $	Nationwide TCI, $/yr	TAC per model, $/yr	Nationwide TAC, $/yr	Uncontrolled emissions, Mg/yr: organics	Uncontrolled emissions, Mg/yr: HCl	Created HCl, Mg/yr (e)	Uncontrolled HAP emissions per process, Mg/yr	Baseline HAP emissions per process, Mg/yr (f)	HAP emissions at floor per process, Mg/yr (g)	Incremental emission reduction per process, Mg/yr	Nationwide incremental emission reduction, Mg/yr (h)	Overall cost effectiveness, $/Mg
1	d	13	6	19	incinerator	431,000	8,189,000	218,000	4,142,000	13.7	0	0	13.7	2.7	0.3	2.5	46.9	88,400
1	c	35	8	43	condenser	302,000	12,986,000	123,000	5,289,000	13.7	0	0	13.7	2.7	1.4	1.4	58.9	89,800
2	d, noH	8	2	10	incinerator	401,000	4,010,000	188,000	1,880,000	40	66.1	17.9	124.0	13.0	1.6	11.4	114.0	16,500
2	d, H	4	1	5	incinerator/scrubber	475,000	2,375,000	265,000	1,325,000	40	66.1	17.9	124.0	24.8	1.6	23.2	115.8	11,400
2	c, noH	5	1	6	condenser	143,000	858,000	85,000	510,000	40	66.1	0	106.1	12.0	4.7	7.3	43.8	11,600
2	c, H	2		2	scrubber/condenser	145,000	290,000	137,000	274,000	40	66.1	0	106.1	21.2	4.7	16.6	33.1	8,300
3	d	7	6	13	incinerator	972,000	12,636,000	831,000	10,803,000	41	0	0	41.0	8.2	0.8	7.4	95.9	112,600
3	c	7	1	8	condenser	160,000	1,280,000	62,600	500,800	41	0	0	41.0	8.2	4.1	4.1	32.8	15,300
4	d, noH	5	3	8	incinerator	918,000	7,344,000	692,000	5,536,000	102	295	67.8	464.8	42.2	5.7	36.5	292.0	19,000
4	d, H	3		3	incinerator/scrubber	1,446,000	4,338,000	942,000	2,826,000	102	295	67.8	464.8	93.0	5.7	87.3	261.9	10,800
4	c, noH	3		3	condenser	216,000	648,000	76,900	230,700	102	295	0	397.0	38.1	13.2	25.0	74.9	3,100
4	c,H	1		1	scrubber/condenser	226,000	226,000	210,000	210,000	102	295	0	397.0	79.4	13.2	66.3	66.3	3,200
4	s, d, H		1	1	scrubber	528,000	528,000	249,000	249,000	102	295	0	397.0	69.2	13.2	56.1	56.1	4,400
		93	29	122			55,708,000		33,775,500								1,236	27,321

(a) "d" means dilute organic HAP concentration; "c" means concentrated organic HAP concentration; "H" means additional HCl control is needed; "noH" means additional HCl control is not needed; "s" means a surveyed process that meets the MACT floor for organic HAP, but not HCl.

(b) All 93 projected processes at the modelled plants are assumed to be at the baseline level of control for organic HAP (80 percent). The distribution between dilute and concentrated processes for models 1 and 2 was based on the ratio of dilute to concentrated streams for batch processes at the surveyed plants. Similarly, the distribution between dilute and concentrated processes for models 3 and 4 was based on the ratio of dilute to concentrated streams for continuous processes at the surveyed plants. The distribution between processes that need additional HCl control and those that do not was also based on the distribution at surveyed plants.

(c) Twenty-eight processes at the surveyed plants had control efficiencies below the MACT floor of 90 percent for organic HAP. In addition, one process had HCl control below the MACT floor level of 94 percent, but organic HAP control was above the MACT floor level of 90 percent. Each of these 29 processes was represented with a model process for the cost analysis. Processes 7, 54, 57, 70, 89, and 90 were represented with model 1d; processes 28, 30, 58, 68, 69, 71, 72, and 73 were represented with model 1c. Processes 67, 93, and 94 were represented with model 2d (process 67 also required additional HCl control to meet the floor); process 15 was represented with model 2c. Processes 1, 2, 3, 4, 18, and 29 were represented with model 3d; process 62 was represented with model 3c. Processes 27, 31, and 91 were represented with model 4d; process 19 was also represented with model 4d, but without the need for additional controls for organic HAP.

(d) The selected control device for organic HAP was either an incinerator or a condenser, whichever was least costly. Incinerators were the least costly for dilute streams, and condensers were least costly for concentrated streams.

(e) "Created HCl" emissions were calculated assuming all of the organic HAP (methylene chloride for the models) was converted to HCl in the incinerator.

(f) Baseline emissions based on 80% control of organic HAP and 94% control of HCl.

(g) MACT floor emissions based on 90% reduction of organic HAP in condensers, 98% reduction of organic HAP in incinerators, and 99% reduction of HCl in scrubbers.

(h) The total nationwide emissions reductions differ from the reductions in the Environmental Impacts memorandum because the surveyed plants are represented with models in this analysis. Also, the environmental impacts analysis did not include HCl created in combustion-based control devices.

REGULATORY ALTERNATIVE 1 COSTS, EMISSION REDUCTIONS, AND COST EFFECTIVENESS FOR PROCESS VENTS (OVERALL)
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\DATADDR\PVCOSTEF.XLS

Model	HAP content (a)	Number of models: modelled plants (b)	Number of models: surveyed plants (c)	Total	Control device (d)	TCI per model, $	Nationwide TCI, $/yr	TAC per model, $/yr	Nationwide TAC, $/yr	Nationwide incremental TAC, $/yr (e)	Uncontrolled emissions, Mg/yr: organics	Uncontrolled emissions, Mg/yr: HCl	Created HCl (f)	Uncontrolled HAP emissions per process, Mg/yr	MACT floor HAP emissions per process, Mg/yr (g)	HAP emissions at reg alt 1 per process, Mg/yr (h)	Incremental emission reduction per process, Mg/yr	Nationwide incremental emission reduction, Mg/yr (i)	Overall cost effectiveness, $/Mg
1	d	13	6	19	incinerator	431,000	8,189,000	218,000	4,142,000	0	13.7	0	0	13.7	0.3	0.3	0.0	0.0	0
1	c	29	8	37	condenser	302,000	11,174,000	123,000	4,551,000	0	13.7	0	0	13.7	1.4	1.4	0.0	0.0	0
2	d, noH	7	2	9	incinerator	401,000	3,609,000	188,000	1,692,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	d, H	3		3	incinerator/scrubber	475,000	1,425,000	265,000	795,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	c, noH	1		1	condenser	143,000	143,000	85,000	85,000	0	40	66.1	0	106.1	4.7	4.7	0.0	0.0	0
2	c, H	1		1	scrubber/condenser	145,000	145,000	137,000	137,000	0	40	66.1	0	106.1	4.7	4.7	0.0	0.0	0
3	d	7	6	13	incinerator	972,000	12,636,000	831,000	10,803,000	0	41	0	0	41.0	0.8	0.8	0.0	0.0	0
3	c	6	1	7	condenser	160,000	1,120,000	62,600	438,200	0	41	0	0	41.0	4.1	4.1	0.0	0.0	0
4	d, noH	3	2	5	incinerator	918,000	4,590,000	692,000	3,460,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	d, H	1		1	incinerator/scrubber	1,446,000	1,446,000	942,000	942,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	c, noH	2		2	condenser	216,000	432,000	76,900	153,800	0	102	295	0	397.0	13.2	13.2	0.0	0.0	0
4	c, H			0	scrubber/condenser	226,000	0	210,000	0	0	102	295	0	397.0	13.2	13.2	0.0	0.0	0
4	s, d, H		1	1	scrubber	528,000	528,000	249,000	249,000	0	102	295	0	397.0	13.2	13.2	0.0	0.0	0
1	c, 98	6		6	condenser	356,000	2,136,000	138,000	828,000	90,000	13.7	0	0	13.7	1.4	0.3	1.1	6.6	13,700
2	d, noH, 98	1		1	incinerator	401,000	401,000	188,000	188,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	d, H, 98	1	1	2	incinerator/scrubber	475,000	950,000	265,000	530,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	c, noH, 98	4	1	5	condenser	159,000	795,000	88,100	440,500	15,500	40	66.1	0	106.1	4.7	1.5	3.2	16.0	1,000
2	c, H, 98	1		1	scrubber/condenser	161,000	161,000	140,000	140,000	3,000	40	66.1	0	106.1	4.7	1.5	3.2	3.2	900
3	c, 98	1		1	condenser	181,000	181,000	67,900	67,900	5,300	41	0	0	41.0	4.1	0.8	3.3	3.3	1,600
4	d, noH, 98	2	1	3	incinerator	918,000	2,754,000	692,000	2,076,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	d, H, 98	2		2	incinerator/scrubber	1,446,000	2,892,000	942,000	1,884,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	c, noH, 98	1		1	condenser	252,000	252,000	85,900	85,900	9,000	102	295	0	397.0	13.2	5.0	8.2	8.2	1,100
4	c, H, 98	1		1	scrubber/condenser	262,000	262,000	219,000	219,000	9,000	102	295	0	397.0	13.2	5.0	8.2	8.2	1,100
		93	29	122			56,221,000		33,907,300	131,800								45.4	2,900

(a) "d" means dilute organic HAP concentration; "c" means concentrated organic HAP concentration; "H" means additional HCl control is needed; "noH" means additional HCl control is not needed; "s" means a surveyed process that meets the MACT floor for organic HAP but not HCl; "98" means the vent stream meets the applicability criteria for 98% control of organic HAP.

(b) All 93 projected processes at the modelled plants are assumed to be at the baseline level of control for organic HAP (80 percent). The distribution between dilute and concentrated processes for models 1 and 2 was based on the ratio of dilute to concentrated streams for batch processes at the surveyed plants. Similarly, the distribution between dilute and concentrated processes for models 3 and 4 was based on the ratio of dilute to concentrated streams for continuous processes at the surveyed plants. The distribution between processes that need additional HCl control and those that do not was also based on the distribution at surveyed plants. The distribution between the processes that require 98% control of organic HAP and those that do not is also based on the distribution of such streams at the surveyed plants.

(c) Twenty-eight processes at the surveyed plants had control efficiencies below the MACT floor of 90 percent for organic HAP. In addition, one process had HCl control below the MACT floor level of 94 percent, but organic HAP control was above the MACT floor level of 90 percent. Each of these 29 processes was represented with a model process for the cost analysis. Processes 7, 54, 57, 70, 89, and 90 were represented with model 1d; processes 28, 30, 58, 68, 69, 71, 72, and 73 were represented with model 1c. Processes 67, 93, and 94 were represented with model 2d (process 67 also required additional HCl control to meet the floor); process 15 was represented with model 2c (and it meets the criteria for 98% control of organic HAP). Processes 1, 2, 3, 4, 18, and 29 were represented with model 3d; process 62 was represented with model 3c. Processes 27, 31, and 91 were represented with model 4d (process 27 also meets the criteria for 98% control of organic HAP); process 19 was also represented with model 4d, but without the need for additional controls for organic HAP.

(d) The selected control device for organic HAP was either an incinerator or a condenser, whichever was least costly. Incinerators were the least costly for dilute streams, and condensers were least costly for concentrated streams.

(e) The incremental cost is zero for the first 13 models because the regulatory alternative requirements are the same as the MACT floor requirements. The incremental costs for all other models based on incinerator control are also zero because the incinerator achieved 98% reduction of organics in the MACT floor analysis. The incremental cost for models based on on condenser control of organics is positive because the cost to achieve 98% control is greater than the cost to achive 90% control.

(f) "Created HCl" emissions were calculated assuming all of the organic HAP (methylene chloride for the models) was converted to HCl in the incinerator.

(g) MACT floor emissions based on 90% reduction of organic HAP in condensers, 98% reduction of organic HAP in incinerators, and 99% reduction of HCl in scrubbers.

(h) RA1 emissions based on either 90% or 98% reduction of organic HAP in condensers, 98% reduction of organic HAP in incinerators, and 99% reduction of HCl in scrubbers.

(i) The total nationwide emissions reductions differ from the reductions in the Environmental Impacts memorandum because the surveyed plants are represented with models in this analysis. Also, the environmental impacts analysis did not include HCl created in combustion-based control devices.

REGULATORY ALTERNATIVE 2 COSTS, EMISSION REDUCTIONS, AND COST EFFECTIVENESS FOR PROCESS VENTS (OVERALL)
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\DATADDR\PVCOSTEF.XLS

Model	HAP content (a)	Number of models modelled plants (b)	Number of models surveyed plants (c)	Total	Control device (d)	TCI per model, $	Nationwide TCI, $/yr	TAC per model, $/yr	Nationwide TAC, $/yr	Nationwide incremental TAC, $/yr (e)	Uncontrolled emissions, Mg/yr organics	Uncontrolled emissions, Mg/yr HCl	Created HCl (f)	Uncontrolled HAP emissions per process, Mg/yr	Reg alt 1 HAP emissions per process, Mg/yr (g)	HAP emissions at reg alt 2 per process, Mg/yr (h)	Incremental emission reduction per process, Mg/yr	Nationwide incremental emission reduction, Mg/yr (i)	Overall cost effectiveness, $/Mg
1	d	13	6	19	incinerator	431,000	8,189,000	218,000	4,142,000	0	13.7	0	0	13.7	0.3	0.3	0.0	0.0	0
1	c	29	8	37	condenser	356,000	13,172,000	138,000	5,106,000	555,000	13.7	0	0	13.7	1.4	0.3	1.1	40.6	13,700
2	d, noH	7	2	9	incinerator	401,000	3,609,000	188,000	1,692,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	d, H	3		3	incinerator/scrubber	475,000	1,425,000	265,000	795,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	c, noH	1		1	condenser	159,000	159,000	88,100	88,100	3,100	40	66.1	0	106.1	4.7	1.5	3.2	3.2	1,000
2	c, H	1		1	scrubber/condenser	161,000	161,000	140,000	140,000	3,000	40	66.1	0	106.1	4.7	1.5	3.2	3.2	900
3	d	7	6	13	incinerator	972,000	12,636,000	831,000	10,803,000	0	41	0	0	41.0	0.8	0.8	0.0	0.0	0
3	c	6	1	7	condenser	181,000	1,267,000	67,900	475,300	37,100	41	0	0	41.0	4.1	0.8	3.3	23.0	1,600
4	d, noH	3	2	5	incinerator	918,000	4,590,000	692,000	3,460,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	d, H	1		1	incinerator/scrubber	1,446,000	1,446,000	942,000	942,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	c, noH	2		2	condenser	252,000	504,000	85,900	171,800	18,000	102	295	0	397.0	13.2	5.0	8.2	16.3	1,100
4	c, H			0	scrubber/condenser	262,000	0	219,000	0	0	102	295	0	397.0	13.2	5.0	8.2	0.0	0
4	s, d, H		1	1	incinerator/scrubber	1,446,000	1,446,000	941,000	941,000	692,000	102	295	0	397.0	13.2	5.0	8.2	8.2	84,800
1	c, 98	6		6	condenser	356,000	2,136,000	138,000	828,000	0	13.7	0	0	13.7	0.3	0.3	0.0	0.0	0
2	d, noH, 98	1		1	incinerator	401,000	401,000	188,000	188,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	d, H, 98	1	1	2	incinerator/scrubber	475,000	950,000	265,000	530,000	0	40	66.1	17.9	124.0	1.6	1.6	0.0	0.0	0
2	c, noH, 98	4	1	5	condenser	159,000	795,000	88,100	440,500	0	40	66.1	0	106.1	1.5	1.5	0.0	0.0	0
2	c, H, 98	1		1	scrubber/condenser	161,000	161,000	140,000	140,000	0	40	66.1	0	106.1	1.5	1.5	0.0	0.0	0
3	c, 98	1		1	condenser	181,000	181,000	67,900	67,900	0	41	0	0	41.0	0.8	0.8	0.0	0.0	0
4	d, noH, 98	2	1	3	incinerator	918,000	2,754,000	692,000	2,076,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	d, H, 98	2		2	incinerator/scrubber	1,446,000	2,892,000	942,000	1,884,000	0	102	295	67.8	464.8	5.7	5.7	0.0	0.0	0
4	c, noH, 98	1		1	condenser	252,000	252,000	85,900	85,900	0	102	295	0	397.0	5.0	5.0	0.0	0.0	0
4	c, H, 98	1		1	scrubber/condenser	262,000	262,000	219,000	219,000	0	102	295	0	397.0	5.0	5.0	0.0	0.0	0
		93	29	122			59,388,000		35,215,500	1,308,200								94	13,859

(a) "d" means dilute organic HAP concentration; "c" means concentrated organic HAP concentration; "H" means additional HCl control is needed; "noH" means additional HCl control is not needed; "s" means a surveyed process that meets the MACT floor for organic HAP but not HCl; "98" means the vent stream meets the applicability criteria for 98% control of organic HAP.

(b) All 93 projected processes at the modelled plants are assumed to be at the baseline level of control for organic HAP (80 percent). The distribution between dilute and concentrated processes for models 1 and 2 was based on the ratio of dilute to concentrated streams for batch processes at the surveyed plants. Similarly, the distribution between dilute and concentrated processes for models 3 and 4 was based on the ratio of dilute to concentrated streams for continuous processes at the surveyed plants. The distribution between processes that need additional HCl control and those that do not was also based on the distribution at surveyed plants. The distribution between the processes that require 98% control of organic HAP and those that do not (under RA1) is also based on the distribution of such streams at the surveyed plants; all processes require 98% control under RA2.

(c) Twenty-eight processes at the surveyed plants had control efficiencies below the MACT floor of 90 percent for organic HAP. In addition, one process had HCl control below the MACT floor level of 94 percent, but organic HAP control was above the MACT floor level of 90 percent. Each of these 29 processes was represented with a model process for the cost analysis. Processes 7, 54, 57, 70, 89, and 90 were represented with model 1d; processes 28, 30, 58, 68, 69, 71, 72, and 73 were represented with model 1c. Processes 67, 93, and 94 were represented with model 2d (process 67 also required additional HCl control to meet the floor); process 15 was represented with model 2c (and it meets the criteria for 98% control of organic HAP). Processes 1, 2, 3, 4, 18, and 29 were represented with model 3d; process 62 was represented with model 3c. Processes 27, 31, and 91 were represented with model 4d (process 27 also meets the criteria for 98% control of organic HAP); process 19 was also represented with model 4d, but without the need for additional controls for organic HAP.

(d) The selected control device for organic HAP was either an incinerator or a condenser, whichever was least costly. Incinerators were the least costly for dilute streams, and condensers were least costly for concentrated streams.

(e) The incremental cost is zero for all models that meet the criteria for 98% control under RA1 because RA2 also requires 98% control. The incremental costs for all other models based on incinerator control are also zero because the incinerator achieved 98% reduction of organics for all models in the RA1 analysis. The incremental cost for models based on on condenser control of organics is positive because the cost to achieve 98% control is greater than the cost to achive 90% control.

(f) "Created HCl" emissions were calculated assuming all of the organic HAP (methylene chloride for the models) was converted to HCl in the incinerator.

(g) RA1 emissions based on either 90% or 98% reduction of organic HAP in condensers, 98% reduction of organic HAP in incinerators, and 99% reduction of HCl in scrubbers.

(h) RA2 emissions based 98% reduction of organic HAP in condensers, 98% reduction of organic HAP in incinerators, and 99% reduction of HCl in scrubbers.

(i) The total nationwide emissions reductions differ from the reductions in the Environmental Impacts memorandum because the surveyed plants are represented with models in this analysis. Also, the environmental impacts analysis did not include HCl created in combustion-based control devices.

CONDENSER COST ALGORITHM (MACT floor)		Variables and equations
Model number:	2	
Required condenser control efficiency:	0.9	eff
Waste Gas Parameters		
Mass flux of HAP, lb/yr	88,200	
Flowrate, scfm	21	Qin
Flowrate, acfm	21	
Temperature, degrees C		
- degrees C	25	
- degrees F	77	Tin
Pressure, mm Hg	760	Ptot
HAP molecular weight	85	MWhap
VOC mole fraction	0.11324	yin
VOC concentration, ppmv	113,235	
Non condensable mole fraction	0.8868	
Operating hours		
Vent	2,800	Vh
Control device	8,760	CDh
Ratio of HAP venting time to control device operating time	0.3196	Ratio=Vh/CDh
Condenser design calculations		
HAP pollutant	MeCl2	
Antoine equation constants		
A	7.409	A
B	1325.9	B
C	252.6	C
HAP partial pressure at outlet, mm Hg	9.582	PP=(Ptot)(yin)(1-eff)/(1-(yin)(eff))
- assumes ideal gas		
HAP mole fraction at outlet	0.01261	yout=PP/Ptot
Condensation temperature		
- degrees C	-46.32	Tdegc=((B/(A-log10PP))-C)
- degrees F	-51.37	TCON=(Tdegc)(1.8)+32
Condenser exit flowrate, ft3/min	14.35	
HAP critical temperature		
Molar heat of condensation, Btu/lbmole		
- at 25 degrees C		
- at TCON	13,005	Hcon
Molar heat capacity of HAP, Btu/lbmole/deg F	32.30	Cphap
Molar heat capacity of air, Btu/lbmole/deg F	6.95	Cpair
Average characteristics during venting events		
HAP in inlet stream		
- lbmole/hr	0.3640	Min=(Qin)(yin)(60 min/hr)/(392 sft3/lbmole)
- lb/hr	30.94	LBin=(Min)(MWhap)
HAP in outlet stream		
- lbmole/hr	0.036397	Mout=(Min)(1-eff)
- lb/hr	3.094	LBout=(Mout)(MWhap)
Heat load, Btu/hr		
Enthalpy change of condensed HAP	5,618	DELHcon=(Min-Mout)(Hcon+(Cphap)(Tin-TCON))
Enthalpy change of noncondensed HAP	151	DELHuncon=(Mout)(Cphap)(Tin-TCON)
Enthalpy change of noncondensible "air"	2,543	DELHair=(((Qin)(60 min/hr)/(392))-(Min))(Cpair)(Tin-TCON)
Total enthalpy change		
- Btu/hr	8,312	LOADmax=DELHcon+DELHuncon+DELHair
- tons	0.693	Rmax=(LOADmax)/12,000
Heat load during non venting periods		
- Btu/hr (assumed to be 10% of max load)	831	LOADmin=(LOADmax)(0.1)
- tons	0.069	Rmin=(LOADmin)/12,000
Total annual condenser heat load, Btu/yr	28,228,007	
Log mean temperature difference, deg F:	49.90	
Coolant flow rate, lb/hr	511	Qcool

Manifolding design parameters		
Diameter of collection main (ft):	0.116	D=((4)(Qin)/2,000/PI)^0.5
- calculated assuming a velocity of 2,000 ft/min		
Length of duct, ft	300	L
Total number of vents	6	Vents
Number of elbows per vent	2	N
Costing factors:		
Operator labor wage rate, $/hr	$15.64	WRo
Maintenance labor wage rate, $/hr	$17.20	WRm
Operating labor, hr/8-hr operation	0.5	
Supervisory labor, % of operating labor	15	
Maintenance labor, hr/8-hr operation	0.5	
Monitoring maintenance labor, hr/8-hr operation	0.5	
Utility requirements		
Electricity, kwh/yr	19,449	Kwh=((Rmax)(Ratio)+(Rmin)(1-Ratio))*((-0.06973)(TCON) +3.446)*(CDh/0.85)
Chemical Engineering Magazine Cost Indexes		
June 1995 plant index	382	
Feb 1989 plant index	352.4	
August 1990 plant index	354.8	
Unit costs (June 1995 dollars)		
Detonation arrestor, $/ea	5,000	DAone
Stainless round duct, $/ft	4.22	Duct=(0.85)(Qin)^0.5(382/352.4)
Elbows, $/ea	6.97	Eone=(0.85)(1.65)(Qin)^0.5(382/352.4)
Automatic damper, $/ea	791.16	ADone=(215*Qin^0.5+722)(382/352.4)
Refrigeration unit cost, $	25,469	RU=(exp(9.73-0.012*TCON+0.584*ln(Rmax)))(382/354.8)
-multistage packaged unit		
Capital Costs (June 1995 dollars),$		
Equipment costs, $		
Packaged refrigeration system	31,836	ECR=(1.25)(RU)
- includes instrumentation		
Auxiliary equipment (manifolding) costs		
Automatic damper (assume 1 per manifold)	791	AD=ADone
Total round duct cost	1,267	RD=(Duct)(L)
Total elbow cost (2/vent)	84	Eall=(Eone)(Vents)(N)
Detonation arrestors (1/vent)	30,000	DA=(DAone)(Vents)
Total	32,141	ECA=Eall+RD+AD+DA
Purchased equipment cost		
Packaged refrigeration system	34,383	PECr+(ECR)(1.08)
Auxiliary equipment	37,927	PECa=(ECA)(1.18)
Installation cost		
Packaged refrigeration system	5,157	Ir=(PECr)(0.15)
Auxiliary equipment (assume equal to PEC)	37,927	Ia=PECa
Monitoring costs		
Initial Performance test for condenser	24,420	TEST
Thermocouple and datalogger	3,000	TD
TOTAL CAPITAL INVESTMENT	142,814	TCI=PECr+PECa+Ir+Ia+TEST+TD
Annual Costs, $/yr		
Direct annual costs		
Operating labor:	8,563	OL=(0.5 hr/8-hr shift)(WRo)(CDh)
Monitoring labor:	8,563	MONL=(0.5 hr/8-hr shift)(WRo)(CDh)
Supervisor labor:	2,569	SL=(0.15)(OL+MONL)

Maintenance labor:	9,419	ML=(0.5 hr/8-hr shift)(WRm)(CDh)
Maintenance materials:	9,419	MM=ML
Monitoring maintenance materials (supplies):	500	MONM
Electricity:	1,148	ELEC=(Kwh)($0.059/kwh)
Indirect annual costs		
Overhead	23,420	O=(0.6)(OL+SL+ML+MONL+MM+MONM)
Property taxes, insurance, administrative charges:	5,713	PTIA=(0.04)(TCI)
Capital Recovery	15,681	CR=(CRF)(TCI)
- CRF, 0.1098, based on 15 yrs and 7% interest		
TOTAL ANNUAL COST, $/yr	84,994	TAC=OL+SL+ML+MM+MONL+MONM+ELEC +O+PTIA+CR
Emission reduction, Mg/yr	36.04	
COST EFFECTIVENESS, $/Mg	$2,358	

CONDENSER COST ALGORITHM (Reg alt)		Variables and equations
Model number:	2	
Required condenser control efficiency:	0.98	eff
Waste Gas Parameters		
Mass flux of HAP, lb/yr	88,200	
Flowrate, scfm	21	Qin
Flowrate, acfm	21	
Temperature, degrees C		
- degrees C	25	
- degrees F	77	Tin
Pressure, mm Hg	760	Ptot
HAP molecular weight	85	MWhap
VOC mole fraction	0.11324	yin
VOC concentration, ppmv	113,235	
Non condensable mole fraction	0.8868	
Operating hours		
Vent	2,800	Vh
Control device	8,760	CDh
Ratio of HAP venting time to control device operating time	0.3196	Ratio=Vh/CDh
Condenser design calculations		
HAP pollutant	MeCl2	
Antoine equation constants		
A	7.409	A
B	1325.9	B
C	252.6	C
HAP partial pressure at outlet, mm Hg	1.936	PP=(Ptot)(yin)(1-eff)/(1-(yin)(eff))
- assumes ideal gas		
HAP mole fraction at outlet	0.00255	yout=PP/Ptot
Condensation temperature		
- degrees C	-66.43	Tdegc=((B/(A-log10PP))-C)
- degrees F	-87.58	TCON=(Tdegc)(1.8)+32
Condenser exit flowrate, ft3/min	12.95	
HAP critical temperature		
Molar heat of condensation, Btu/lbmole		
- at 25 degrees C		
- at TCON	13,005	Hcon
Molar heat capacity of HAP, Btu/lbmole/deg F	32.30	Cphap
Molar heat capacity of air, Btu/lbmole/deg F	6.95	Cpair
Average characteristics during venting events		
HAP in inlet stream		
- lbmole/hr	0.3640	Min=(Qin)(yin)(60 min/hr)/(392 sft3/lbmole)
- lb/hr	30.94	LBin=(Min)(MWhap)
HAP in outlet stream		
- lbmole/hr	0.007279	Mout=(Min)(1-eff)
- lb/hr	0.619	LBout=(Mout)(MWhap)
Heat load, Btu/hr		
Enthalpy change of condensed HAP	6,535	DELHcon=(Min-Mout)(Hcon+(Cphap)(Tin-TCON))
Enthalpy change of noncondensed HAP	39	DELHuncon=(Mout)(Cphap)(Tin-TCON)
Enthalpy change of noncondensible "air"	3,260	DELHair=(((Qin)(60 min/hr)/(392))-(Min))(Cpair)(Tin-TCON)
Total enthalpy change		
- Btu/hr	9,834	LOADmax=DELHcon+DELHuncon+DELHair
- tons	0.819	Rmax=(LOADmax)/12,000
Heat load during non venting periods		
- Btu/hr (assumed to be 10% of max load)	983	LOADmin=(LOADmax)(0.1)
- tons	0.082	Rmin=(LOADmin)/12,000
Total annual condenser heat load, Btu/yr	33,395,783	
Log mean temperature difference, deg F:	49.90	
Coolant flow rate, lb/hr	605	Qcool

Manifolding design parameters		
Diameter of collection main (ft):	0.116	D=((4)(Qin)/2,000/PI)^0.5
- calculated assuming a velocity of 2,000 ft/min		
Length of duct, ft	300	L
Total number of vents	6	Vents
Number of elbows per vent	2	N
Costing factors:		
Operator labor wage rate, $/hr	$15.64	WRo
Maintenance labor wage rate, $/hr	$17.20	WRm
Operating labor, hr/8-hr operation	0.5	
Supervisory labor, % of operating labor	15	
Maintenance labor, hr/8-hr operation	0.5	
Monitoring maintenance labor, hr/8-hr operation	0.5	
Utility requirements		
Electricity, kwh/yr	31,277	Kwh=((Rmax)(Ratio)+(Rmin)(1-Ratio))*((-0.06973)(TCON) +3.446)*(CDh/0.85)
Chemical Engineering Magazine Cost Indexes		
June 1995 plant index	382	
Feb 1989 plant index	352.4	
August 1990 plant index	354.8	
Unit costs (June 1995 dollars)		
Detonation arrestor, $/ea	5,000	DAone
Stainless round duct, $/ft	4.22	Duct=(0.85)(Qin)^0.5(382/352.4)
Elbows, $/ea	6.97	Eone=(0.85)(1.65)(Qin)^0.5(382/352.4)
Automatic damper, $/ea	791.16	ADone=(215*Qin^0.5+722)(382/352.4)
Refrigeration unit cost, $	35,768	RU=(exp(9.73-0.012*TCON+0.584*ln(Rmax)))(382/354.8)
-multistage packaged unit		
Capital Costs (June 1995 dollars),$		
Equipment costs, $		
Packaged refrigeration system	44,710	ECR=(1.25)(RU)
- includes instrumentation		
Auxiliary equipment (manifolding) costs		
Automatic damper (assume 1 per manifold)	791	AD=ADone
Total round duct cost	1,267	RD=(Duct)(L)
Total elbow cost (2/vent)	84	Eall=(Eone)(Vents)(N)
Detonation arrestors (1/vent)	30,000	DA=(DAone)(Vents)
Total	32,141	ECA=Eall+RD+AD+DA
Purchased equipment cost		
Packaged refrigeration system	48,286	PECr+(ECR)(1.08)
Auxiliary equipment	37,927	PECa=(ECA)(1.18)
Installation cost		
Packaged refrigeration system	7,243	Ir=(PECr)(0.15)
Auxiliary equipment (assume equal to PEC)	37,927	Ia=PECa
Monitoring costs		
Initial Performance test for condenser	24,420	TEST
Thermocouple and datalogger	3,000	TD
TOTAL CAPITAL INVESTMENT	158,803	TCI=PECr+PECa+Ir+Ia+TEST+TD
Annual Costs, $/yr		
Direct annual costs		
Operating labor:	8,563	OL=(0.5 hr/8-hr shift)(WRo)(CDh)
Monitorine labor:	8,563	MONL=(0.5 hr/8-hr shift)(WRo)(CDh)
Supervisor labor:	2,569	SL=(0.15)(OL+MONL)
Maintenance labor:	9,419	ML=(0.5 hr/8-hr shift)(WRm)(CDh)
Maintenance materials:	9,419	MM=ML
Monitoring maintenance materials (supplies):	500	MONM
Electricity:	1,845	ELEC=(Kwh)($0.059/kwh)
Indirect annual costs		

Overhead	23,420	O=(0.6)(OL+SL+ML+MONL+MM+MONM)
Property taxes, insurance, administrative charges:	6,352	PTIA=(0.04)(TCI)
Capital Recovery	17,437	CR=(CRF)(TCI)
- CRF, 0.1098, based on 15 yrs and 7% interest		
TOTAL ANNUAL COST, $/yr	88,087	TAC=OL+SL+ML+MM+MONL+MONM+ELEC +O+PTIA+CR
Emission reduction, Mg/yr	39.24	
COST EFFECTIVENESS, $/Mg	$2,245	

TOTAL ANNUAL COST SPREADSHEET PROGRAM--GAS ABSORBERS [1]

COST BASE DATE: Third Quarter 1991 [2]

VAPCCI (Second Quarter 1995): [3] 106.1

INPUT PARAMETERS:

Model inputs	
-- Model number	2c
-- Gas conditions out of process or incinerator	
-- Gas flow rate, scfm	16
-- Gas temperature, deg. F	77
-- Gas conditions into absorber (saturated)	
-- Gas flow rate, scfm	16
-- Gas temperature, deg. F	65
-- Inlet HCl concentration, mole fraction	0.444
-- Vent operating hours, hr/yr	2,800
-- Control device operating hours, hr/yr	8,760

Stream parameters:

-- Inlet waste gas flowrate (acfm):	16
-- Inlet waste gas temperature (oF):	65
-- Inlet waste gas pressure (atm.):	1
-- Pollutant in waste gas:	Hydrogen chloride (HCl)
-- Inlet gas poll. conc., yi (mole fraction):	0.444
-- Pollutant removal efficiency (fraction):	0.99
-- Solvent:	Aqueous caustic soda
-- Inlet pollutant conc. in solvent:	0
-- Waste gas molecular weight (lb/lb-mole):	29.00
-- Solvent molecular weight (lb/lb-mole):	18
-- Inlet waste gas density (lb/ft3):	0.0757
-- Solvent density (lb/ft3):	62.4
-- Solvent specific gravity:	1
-- Waste gas viscosity @ inlet temp. (lb/ft-hr):	0.044
-- Solvent viscosity @ inlet temp. (lb/ft-hr):	2.16
-- Minimum wetting rate (ft2/hr):	1.3
-- Pollutant diffusivity in air (ft2/hr):	0.725
-- Pollutant diffusivity in solvent (ft2/hr):	0.000102

Packing parameters:

-- Packing type:	1-in ceramic Raschig rings	1-in ceramic Raschig rings
-- Packing factor, Fp:	160	160
-- Packing constant, alpha:	6.41	6.41
-- Packing constant, beta:	0.32	0.32
-- Packing constant, gamma:	0.51	0.51
-- Packing constant, phi:	0.00357	0.00357
-- Packing constant, b:	0.35	0.35
-- Packing constant, c:	0.97	0.97
-- Packing constant, j:	0.25	0.25
-- Surface area-to-volume ratio, a (ft2/ft3):	58	58
-- Packing cost ($/ft3):	35	35

DESIGN PARAMETERS:

-- Material of construction (see list below):[4]	1	
-- Inlet pollutant concentration (free basis) (Yi):	7.985612E-01	
-- Outlet pollutant concentration (free basis) (Yo):	0.0079856	
-- Out. eq. poll. conc. in solv., Xo* (op. line):	0.16	check for each model
-- Theoretical operating line slope (Ls/Gs,min.):	4.9411	
-- Ls/Gs adjustment factor:	1.5	
-- Actual operating line slope (Ls/Gs, act.):	7.4116	
-- Gas flowrate, Gs (free basis, lb-moles/hr):	1	
-- Solvent flowrate, Ls (free basis, lb-mol/hr):	10.09	
-- Gas flowrate, Gmol,i (lb-moles/hr):	2	
-- Solvent flowrate, Lmol,i (lb-moles/hr):	10.09	
-- Outlet actual pollutant conc. in solv., Xo:	0.1067	
-- Gas poll. conc. in eq. with Xo (Yo*):	0.0001	check for each model
-- Outlet solv. poll. conc. (mol frac basis,xo):	0.0964	
-- Gas poll. conc., yo* (mole fract. basis):	0.0001	
-- Outlet gas poll. conc., yo (mole fract.):	0.00792	
-- Slope of equilibrium line (m):	0.00104	
-- Absorption factor (AF)--first calculation:	7144.47	
-- ABSCISSA (column diameter calculation):	0.16020	
-- ORDINATE (column diameter calculation):	0.0971	
-- Superficial gas flowrate, Gsfr,i (lb/sec-ft2)	0.3071	
-- Flooding factor, f:	0.7	
-- Column cross-sectional area, A (ft2):	0.05	
-- Superficial liq flowrate (lb/hr-ft2) (Lsfr,i):	3559.64	
-- Minimum liquid flowrate (lb/hr-ft2):	4,705	
-- If Superficial liquid flowrate is < minimum needed, the minimum must be used to calculate tower area and diameter (iteratively):		
-- guess A iteratively until the two ORDINATE values below agree, ft2	0.102	
-- recalculate Lmol,i	27	
-- calculate ABSCISSA for Fig. 9.5	0.23532	
-- calculate Gsfr,i from Eq. 9-21	0.2763	
-- calculate ORDINATE for Fig. 9.5 using eq. 9.54	0.0785	
-- calculate ORDINATE from eq. 9-19	0.0788	
-- Absorption factor--based on min liq flowrate		
-- Xo	1.21E-02	
-- xo	1.23E-02	
-- AF	7,144.47	
-- Values to use in subsequent calculations		
-- Lsfr,i	4,705	
-- A	0.102	
-- Gsfr,i	0.2763	
-- AF	7,144.47	
-- Column diameter, D (ft2):	0.360	
-- Number of transfer units, Ntu:	4.027	
-- Gas film transfer coefficient, Hg (ft):	0.625	
-- Liquid film transfer coefficient, Hl (ft):	0.969	
-- Height of a transfer unit (ft):	0.625	
-- Packing depth (ft):	2.516	
-- Column total height (ft):	6.70	
-- Column surface area (ft2):	7.8	
-- Column gas pressure drop (in. w.c./ft packing):	1.017	

-- Column liquid pressure drop (ft of H2O):	60
-- Packing volume (ft3):	0.3

CAPITAL COSTS:

Equipment costs ($):	
-- Gas absorber	896
-- Pump (assumes $16/gpm)	15
-- Packing	9
-- Total (base)	920
' (escalated)	1,026
Purchased Equipment Cost ($):	1,210
Total Capital Investment ($):	2,662

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ANNUAL COST INPUTS:

Control device operating factor (hr/yr):	8,760
Vent operating factor, hr/yr	2,800
Operating labor rate ($/hr):	15.64
Maintenance labor rate ($/hr):	17.20
Operating labor factor (hr/sh):	0.0
Maintenance labor factor (hr/sh):	0.5
Electricity price ($/kWhr):	0.059
Caustic price ($/ton):	300
Solvent (water) price ($/1000 gal):	0.2
Wastewater trtmt cost ($/1000 gal):	3.80
Overhead rate (fraction):	0.6
Annual interest rate (fraction):	0.07
Control system life (years):	15
Capital recovery factor (system):	0.1098
Taxes, insurance, admin. factor:	0.04

ANNUAL COSTS:

Item	Cost ($/yr)	Wt. Factor	W.F.(cond.)
Operating labor	0	0.000	----
Supervisory labor	0	0.000	----
Maintenance labor	9,419	0.182	----
Maintenance materials	9,419	0.182	----
Electricity [5]	4	0.000	----
Caustic	18,627	0.359	----
Quench water	0	0.000	----
Solvent (water)	134	0.003	----
Wastewater treatment	2,539	0.049	----
Overhead	11,303	0.218	0.581
Taxes, insurance, administrative	106	0.002	----
Capital recovery	292	0.006	0.008
Total Annual Cost	51,844	1.000	1.000

NOTES:

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[1] This program has been based on data and procedures in Chapter 9 of the OAQPS CONTROL COST MANUAL (4th edition).

[2] Base equipment costs reflect this date.

[3] VAPCCI = Vatavuk Air Pollution Control Cost Index (for gas absorbers) corresponding to year and quarter shown. Base equipment cost, purchased equipment cost, and total capital investment have been escalated to this date via the VAPCCI and control equipment vendor data.

[4] Enter one of the following: fiberglass-reinforced plastic (FRP)--'1' ; 304 stainless steel--'1.4'; polypropylene--'0.95'; polyvinyl chloride (PVC)--'0.70'.

[5] Does not include electricity for fan because fan electricity is included in the incinerator or condenser algorithm.

THERMAL INCINERATOR COST ALGORITHM

Process vents model:	2		
Waste gas parameters			HAP'S CONTROLLED (98% of input), Mg/yr
1. Mass flux of HAP, lb/yr	88,200		39.24
1. Volumetric flow rate, scfm	2,080.0		
2. HAP concentration, ppmv	1,143		COST EFFECTIVENESS ($/Mg)
3. Assumed heating value of HAPs, Btu/scf HAP	2,000		4,780
4. Temperature, deg. F	77		
5. Molecular weight of HAP	85	MeCl2	
6. Molecular weight of gas	29.06		
Operating hours, hr/yr			
Vents	2,800	Vh	
Control device	8,760	CDh	
Ratio of HAP venting time to control device operating time	0.3196	Ratio=Vh/CDh	
Equipment design parameters		Variables/Equations	
Manifolding			
Number of vents	6	Vents	
Diameter of collection main, ft - calculated assuming velocity of 2,000 ft/min	1.15		
Length of duct, ft	300	L	
Number of elbows in duct per vent	2	N	
Number of dampers	1		
Incinerator			
Energy recovery, percent	70		
Operating temperature, deg. F	1600		
Calculate natural gas requirements			
STEP 1: Calculate total waste gas flow into incinerator			
Calculate O2 content, vol percent	20.98		
Calculate dilution air for combustion, scfm	0.00		
Calculate dilution air for safety, scfm	0.00		
Total gas flow into incinerator, scfm	2080.00	scfmi	
Step 2: Calculate heat content of waste gas into incinerator, Btu/scf	2.29		
Step 3: Calculate waste gas temperature out of preheater, deg. F - calculated assuming amount of auxiliary fuel and dilution air are small so that mass flow rates on both sides of the preheater are about the same.	1,143		
Step 4: Calculate auxiliary fuel required while vent(s) operate, scfm	22.76	FFmin	
STEP 5: Calculate total gas flow out of incinerator while vent(s) operate, scfm	2102.76		
Step 6: Calculate maximum auxiliary fuel flow	28.16	FFmax	

(when no emissions are vented), scfm		
Step 7: Calculate maximum total gas flow out of incinerator, scfm	2108.16	scfm
Utility requirements		
Electricity, kwh/yr	104,434	Kwh=(0.000117)(scfm)(29 in. H20)(CDh)/0.6
- combined fan/motor efficiency of 60 percent		
Natural gas		
--scf/yr	13,892,987	GASft3=((FFmax)(1-Ratio)+(FFmin)(Ratio))(60)(CDh)
--Btu/yr	13,892,987,272	GASbtu=(GASft3)(1,000 Btu/scf)
Chemical Engineering Magazine cost indexes		
June 1995 plant index	382	
Feb 1989 plant index	352.4	
June 1995 equipment index	428.6	
April 1988 plant index	340.1	
	342.5	
Unit costs		
Elbows, $/ea.	69.34	Eone=(0.85)(1.65)(scfm)^0.5(382/352.4)
SS round duct diam. of main, $/ft	42.02	Duct=(0.85)(scfm)^0.5(382/352.4)
Automatic damper, $/ea.	886.77	ADone=(215*scfm^0.5+722)(382/352.4)
Detonation arrestor, $/ea.	5,000	DAone
Operator labor wage rate, $/hr	15.64	WRo
Maintenance labor wage rate, $/hr	17.21	WRm
Capital Costs for Incinerator (June 1995 dollars), $		
Purchased equipment costs		
Equipment		
Recuperative incinerator	182,245	RI=(21,342)(scfm)^0.25(428.6/340.1)
- use 500 scfm when max scfm from step 7 is less than 500		
Instrumentation	18,225	I=(RI)(0.1)
Sales tax	5,467	S=(RI)(0.03)
Freight	9,112	F=(RI)(0.05)
Total purchased equipment cost	215,050	PECi=RI+I+S+F
Direct installation costs	64,515	DI=(PECi)(0.3)
Indirect costs (installation)	66,665	II=(PECi)(0.31)
Total capital investment	346,230	TCIi=PECi+DI+II
Capital Costs for Manifolding (June 1995 dollars), $		
Purchased equipment cost		
Ductwork		
Elbows	832	Eall=(Eone)(Vents)(N)
Round duct	12,607	RD=(Duct)(L)
Automatic damper	887	AD=ADone
Detonation arrestors	30,000	DA=(DAone)(Vents)
Total (w/ instr., sales tax, & freight)	52,304	PECd=(Eall+RD+AD+DA)*1.18
Installation (assume equal to PEC)	52,304	Im=(PECd)
Total capital investment	104,608	TCIm=PECd+Im
Capital Costs for Monitoring (June 1995 dollars), $		
Initial performance test	24,420	TEST
Thermocouple and datalogger	3,000	TD
Total capital investment	400,840	TCI
- If scfm from step 7 < 20,000;		

then TCI=1.25xPECi+TCIm+TEST+TD
- If scfm from step 7 >= 20,000;
then TCI=TCIi+TCIm+TEST+TD

Annual costs, $/yr		
Direct annual costs		
Operating labor		
Control device	8,563	OLc=(0.5hr/8-hr shift)(WRo)(CDh)
Monitoring	8,563	OLm=(0.5hr/8-hr shift)(WRo)(CDh)
Supervisory labor	2,569	SL=(0.15)(OLc+OLm)
Maintenance labor	9,422	ML=(0.5hr/8-hr shift)(WRm)(CDh)
Maintenance materials	9,422	MM=ML
Monitoring supplies	500	MS
Utilities		
Natural gas	45,847	NG=(GASft3)($3.3/1,000 scf)
Electricity	6,162	Elec=(Kwh)($0.059/kwh)
Indirect annual costs		
Overhead	23,424	O=(0.6)(OLc+OLm+SL+ML+MM+MS)
Administrative charges	8,017	A=(0.02)(TCI)
Property tax	4,008	PT=(0.01)(TCI)
Insurance	4,008	INS=(0.01)(TCI)
Capital recovery	57,080	CR=(CRF)(TCI)
- CRF, 0.1424, based on 10-yrs and 7% interest		
Total annual cost, $/yr	187,585	TAC=OLc+OLm+SL+ML+MM+MS+NG+Elec+O+A+PT +INS+CR

TOTAL ANNUAL COST SPREADSHEET PROGRAM--GAS ABSORBERS [1]

COST BASE DATE: Third Quarter 1991 [2]

VAPCCI (Second Quarter 1995): [3] 106.1

INPUT PARAMETERS:

Model inputs	
-- Model number	2d
-- Gas conditions out of process or incinerator	
-- Gas flow rate, scfm	2,011
-- Gas temperature, deg. F	540
-- Gas conditions into absorber (saturated)	
-- Gas flow rate, scfm	2,416
-- Gas temperature, deg. F	130
-- Inlet HCl concentration, mole fraction	0.004902
-- Vent operating hours, hr/yr	2,800
-- Control device operating hours, hr/yr	8,760

Stream parameters:

-- Inlet waste gas flowrate (acfm):	2,654
-- Inlet waste gas temperature (oF):	130
-- Inlet waste gas pressure (atm.):	1
-- Pollutant in waste gas:	Hydrogen chloride (HCl)
-- Inlet gas poll. conc., yi (mole fraction):	0.004902
-- Pollutant removal efficiency (fraction):	0.99
-- Solvent:	Aqueous caustic soda
-- Inlet pollutant conc. in solvent:	0
-- Waste gas molecular weight (lb/lb-mole):	29.00
-- Solvent molecular weight (lb/lb-mole):	18
-- Inlet waste gas density (lb/ft3):	0.0673
-- Solvent density (lb/ft3):	62.4
-- Solvent specific gravity:	1
-- Waste gas viscosity @ inlet temp. (lb/ft-hr):	0.044
-- Solvent viscosity @ inlet temp. (lb/ft-hr):	2.16
-- Minimum wetting rate (ft2/hr):	1.3
-- Pollutant diffusivity in air (ft2/hr):	0.725
-- Pollutant diffusivity in solvent (ft2/hr):	0.000102

Packing parameters:

-- Packing type:	2-in. ceramic Raschig rings	1-in ceramic Raschig rings
-- Packing factor, Fp:	65	160
-- Packing constant, alpha:	3.82	6.41
-- Packing constant, beta:	0.41	0.32
-- Packing constant, gamma:	0.45	0.51
-- Packing constant, phi:	0.0125	0.00357
-- Packing constant, b:	0.22	0.35
-- Packing constant, c:	0.24	0.97
-- Packing constant, j:	0.17	0.25
-- Surface area-to-volume ratio, a (ft2/ft3):	28	58
-- Packing cost ($/ft3):	20	35

DESIGN PARAMETERS:

-- Material of construction (see list below):[4]	1	
-- Inlet pollutant concentration (free basis) (Yi):	4.926148E-03	
-- Outlet pollutant concentration (free basis) (Yo):	0.0000493	
-- Out. eq. poll. conc. in solv., Xo* (op. line):	0.16	check for each model
-- Theoretical operating line slope (Ls/Gs,min.):	0.0305	
-- Ls/Gs adjustment factor:	1.5	
-- Actual operating line slope (Ls/Gs, act.):	0.0457	
-- Gas flowrate, Gs (free basis, lb-moles/hr):	368	
-- Solvent flowrate, Ls (free basis, lb-mol/hr):	16.82	
-- Gas flowrate, Gmol,i (lb-moles/hr):	370	
-- Solvent flowrate, Lmol,i (lb-moles/hr):	16.82	
-- Outlet actual pollutant conc. in solv., Xo:	0.1067	
-- Gas poll. conc. in eq. with Xo (Yo*):	0.0001	check for each model
-- Outlet solv. poll. conc. (mol frac basis,xo):	0.0964	
-- Gas poll. conc., yo* (mole fract. basis):	0.0001	
-- Outlet gas poll. conc., yo (mole fract.):	0.00005	
-- Slope of equilibrium line (m):	0.00104	
-- Absorption factor (AF)--first calculation:	44.07	
-- ABSCISSA (column diameter calculation):	0.00093	
-- ORDINATE (column diameter calculation):	0.2061	
-- Superficial gas flowrate, Gsfr,i (lb/sec-ft2)	0.6621	
-- Flooding factor, f:	0.7	
-- Column cross-sectional area, A (ft2):	6.40	
-- Superficial liq flowrate (lb/hr-ft2) (Lsfr,i):	47.35	
-- Minimum liquid flowrate (lb/hr-ft2):	2,271	
-- If Superficial liquid flowrate is < minimum needed, the minimum must be used to calculate tower area and diameter (iteratively):		
-- guess A iteratively until the two ORDINATE values below agree, ft2	6.95	
-- recalculate Lmol,i	877	
-- calculate ABSCISSA for Fig. 9.5	0.04835	
-- calculate Gsfr,i from Eq. 9-21	0.6123	
-- calculate ORDINATE for Fig. 9.5 using eq. 9.54	0.1761	
-- calculate ORDINATE from eq. 9-19	0.1759	
-- Absorption factor--based on min liq flowrate		
-- Xo	1.50E-08	
-- xo	1.50E-08	
-- AF	infinity	
-- Values to use in subsequent calculations		
-- Lsfr,i	2,271	
-- A	6.95	
-- Gsfr,i	0.6123	
-- AF	infinity	
-- Column diameter, D (ft2):	2.975	
-- Number of transfer units, Ntu:	4.600	
-- Gas film transfer coefficient, Hg (ft):	2.272	
-- Liquid film transfer coefficient, Hl (ft):	1.064	
-- Height of a transfer unit (ft):	2.272	
-- Packing depth (ft):	10.452	
-- Column total height (ft):	20.48	
-- Column surface area (ft2):	205.3	
-- Column gas pressure drop (in. w.c./ft packing):	0.838	

-- Column liquid pressure drop (ft of H2O):	60
-- Packing volume (ft3):	72.6

CAPITAL COSTS:

Equipment costs ($):	
-- Gas absorber	23,605
-- Pump (assumes $16/gpm)	505
-- Packing	1,453
-- Total (base)	25,563
' (escalated)	28,495
Purchased Equipment Cost ($):	33,624
Total Capital Investment ($):	73,972

ANNUAL COST INPUTS:

Control device operating factor (hr/yr):	8,760
Vent operating factor, hr/yr	2,800
Operating labor rate ($/hr):	15.64
Maintenance labor rate ($/hr):	17.20
Operating labor factor (hr/sh):	0.0
Maintenance labor factor (hr/sh):	0.5
Electricity price ($/kWhr):	0.059
Caustic price ($/ton):	300
Solvent (water) price ($/1000 gal):	0.2
Wastewater trtmt cost ($/1000 gal):	3.80
Overhead rate (fraction):	0.6
Annual interest rate (fraction):	0.07
Control system life (years):	15
Capital recovery factor (system):	0.1098
Taxes, insurance, admin. factor:	0.04

ANNUAL COSTS:

Item	Cost ($/yr)	Wt. Factor	W.F.(cond.)
Operating labor	0	0.000	----
Supervisory labor	0	0.000	----
Maintenance labor	9,419	0.122	----
Maintenance materials	9,419	0.122	----
Electricity [5]	242	0.003	----
Caustic	31,054	0.402	----
Quench water	188	0.002	----
Solvent (water)	223	0.003	----
Wastewater treatment	4,233	0.055	----
Overhead	11,303	0.146	0.391
Taxes, insurance, administrative	2,959	0.038	----
Capital recovery	8,122	0.105	0.144
Total Annual Cost	77,162	1.000	1.000

NOTES:

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[1] This program has been based on data and procedures in Chapter 9 of the OAQPS CONTROL COST MANUAL (4th edition).

[2] Base equipment costs reflect this date.

[3] VAPCCI = Vatavuk Air Pollution Control Cost Index (for gas absorbers) corresponding to year and quarter shown. Base equipment cost, purchased equipment cost, and total capital investment have been escalated to this date via the VAPCCI and control equipment vendor data.

[4] Enter one of the following: fiberglass-reinforced plastic (FRP)--'1' ; 304 stainless steel--'1.4'; polypropylene--'0.95'; polyvinyl chloride (PVC)--'0.70'.

[5] Does not include electricity for fan because fan electricity is included in the incinerator or condenser algorithm.

ATTACHMENT B

- Inputs to the Condenser Cost Algorithm for Storage Tanks
- Costs and Cost Effectiveness Tables for the Storage Tank MACT Floor and Regulatory Alternative for Existing Sources
- Example IFR Cost Calculation Table (see Attachment A for Condenser Algorithm)

INPUTS TO THE CONDENSER COST ALGORITHM FOR STORAGE TANKS

Model	Total emissions, Mg	Working loss emissions, Mg	Breathing loss emissions, Mg	Tank capacity, gallons	Turnovers[a]
1B	588	345	242	13,300	34.6
2B	1,210	706	505	20,000	10.1
3B	1,930	1,050	877	448,000	5.43

[a]A fill rate of 750 gallons per minute was assumed, providing a flowrate of 100 acfm.

STORAGE TANK CAPITAL COSTS AND ANNUAL COSTS PER MODEL FOR EXISTING SOURCE MACT FLOOR

Model tank[a]		No. of storage tanks nationwide[b]	Control device[c]	Total capital investment, $	Total annual cost, $/yr	Emission reduction from baseline, Mg/yr[d]	Cost effectiveness, $/Mg
Model 1	A	35	None	0	0	0.00	0
	B	35	Condenser	4,133	14,450	0.0973	148,500
	C	90	None	0	0	0.00	0
Model 2	A	30	None	0	0	0.00	0
	B	8	IFR	11,560	2,514	0.5218	4,813
	C	43	None	0	0	0.00	0
Model 3	A	46	None	0	0	0.00	0
	B	16	IFR	39,880	6,901	0.7824	8,812
	C	16	None	0	0	0.00	0

[a]For each size category, Model A is based on storage tanks that are controlled to ≥95 percent and that have uncontrolled HAP emissions ≥110 kg/yr (240 lb/yr).
Model B is based on storage tanks that are controlled to <95 percent and that have uncontrolled HAP emissions ≥110 kg/yr (240 lb/yr).
Model C is based on all storage tanks with uncontrolled HAP emissions <110 kg/yr (240 lb/yr).
[b]Total nationwide number of tanks is 320.
[c]IFR = internal floating roof.
[d]While the MACT floor control level requires 41 percent control efficiency, an IFR control device achieves 95 percent emission reduction. The 95 percent emission reduction of the control device is used to calculate emission reduction for the cost analysis.

STORAGE TANK CAPITAL COSTS AND ANNUAL COSTS PER MODEL FOR EXISTING SOURCE REGULATORY ALTERNATIVE

Model tank[a]		No. of storage tanks nationwide[b]	Control device	Total capital investment, $	Total annual cost, $/yr	Incremental annual cost from MACT floor, $/yr	Incremental emission reduction from MACT floor, Mg/yr[d]	Incremental cost effectiveness from MACT floor, $/Mg
Model 1	A	35	None	0	0	0	0.0000	0
	B	35	Condenser	4,133	14,450	0	0.0000	0
	C	90	None	0	0	0	0.0000	0
Model 2	A	31	None	0	0	0	0.0000	0
	B	8	IFR	11,560	2,514	0	0.0000	0
	C	43	None	0	0	0	0.0000	0
Model 3	A	46	None	0	0	0	0.0000	0
	B	16	IFR	39,880	6,901	0	0.0000	0
	C	16	None	0	0	0	0.0000	0

[a]For each size category, Model A is based on storage tanks that are controlled to ≥95 percent and that have uncontrolled HAP emissions ≥110 kg/yr (240 lb/yr).
Model B is based on storage tanks that are controlled to <95 percent and that have uncontrolled HAP emissions ≥110 kg/yr (240 lb/yr).
Model C is based on all storage tanks with uncontrolled HAP emissions <110 kg/yr (240 lb/yr).
[b]Total nationwide number of tanks is 320.
[c]IFR = internal floating roof.
[d]Because a 95 percent emission reduction was used in the MACT floor emission reduction (for cost analysis), there is no increase in the emission reduction from the floor to the regulatory alternative for the cost analysis.

INTERNAL FLOATING ROOF COSTS FOR STORAGE TANK MODELS

ALUMINUM NONCONTACT IFR WITH VAPOR MOUNTED PRIMARY SEAL AND SECONDARY SEAL

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$ = 3.19(D, ft)^2 + 7,734	1991 DOLLARS
361.3	1991 ANNUAL PLANT INDEX
382.0	JUN 1995 PLANT INDEX
380.8	JAN 1996 PLANT INDEX

		MODEL 2-B	MODEL 3-B
CAPACITY, GALLONS	INPUT FROM MODEL TANK	20,000	448,000
CAPACITY, FT3	GALLONS/7.48 ft3	2,673.80	59,893.05
DIAMETER, FT (ASSUME H IS 1.8xD)	(FT3/0.45/3.14)^0.33	12.4	34.8
INSTALLED CAPITAL COST	1991	8,224.49	11,597.22
$ = 3.19(D, ft)^2 + 7,734	JUN 1995	8,695.70	12,261.66
(ICC)			
DEGASSING AND CLEANING		1,860.00	5,220.00
($150/FT DIAMETER)			
SLUDGE DISPOSAL		1,000.00	22,400.00
($5/GAL, ASSUME 1% SLUDGE VOLUME)			
TOTAL CAPITAL INVESTMENT	JUN 1995	11,555.70	39,881.66
TCI = ICC + DEGAS/CLEAN + SLUDGE DISP			
ANNUALIZED COST	JUN 1995	1,644.38	5,675.16
(7%, 10 YRS : CRF = .1423)			
TAXES, INS, ADMIN	JUN 1995	347.83	490.47
(4% OF ICC)			
OPERATING COST	JUN 1995	521.74	735.70
(6% OF ICC)			
NET ANNUAL COST	JUN 1995	2,513.95	6,901.33

ATTACHMENT C

- Costs and Cost Effectiveness Table for the Wastewater Regulatory Alternative for Existing Sources
- Example Steam Stripper Cost Algorithm for Wastewater Stream 44
- Example Hazardous Waste Disposal Cost Calculation Table

WASTEWATER COSTS AND COST EFFECTIVENESS FOR EXISTING SOURCE REGULATORY ALTERNATIVE
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								REGULATORY ALTERNATIVE, per stream (a)							NATIONWIDE					
	Stream (b)	Flow rate per stream, gal/yr	Load per stream, Mg/yr	ppmw	Baseline and MACT Floor emissions per stream, Mg/yr	Fr	Fe	Removed from load, Mg/yr	Left in water, Mg/yr	Emissions after SS, Mg/yr	Reduction from baseline, Mg/yr	SS TCI, $	SS TAC, $/yr (c)	Disposal as hazardous waste, $/yr (c)	Number of streams to control	TCI, $	TAC, $	Baseline and MACT floor, Mg/yr	Reduction from baseline, Mg/yr (d)	Cost Effectiveness $/Mg
1	13a, 14a, 15a	6,990,000	158	5,971	88.4	0.99	0.56	156	1.58	0.884	87.5	490,632	148,130	4,920,738	1	$490,632	$148,130	88.4	87.5	$1,692
2	17b	5,040,000	479	25,123	306	0.99	0.64	474	4.79	3.07	303	458,185	130,360	3,548,000	1	$458,185	$130,360	306	303	$430
3	18b	2,960,000	281	25,095	180	0.99	0.64	278	2.81	1.80	178	374,002	110,166	2,083,746	1	$374,002	$110,166	180	178	$618
4	27	120,000	13.6	29,958	10.9	0.99	0.8	13.5	0.136	0.109	10.8	319,470	53,972	84,476	3	$958,410	$161,915	32.7	32.4	$5,001
5	32	1,857,146	10.7	1,523	8.57	0.99	0.8	10.6	0.107	0.0856	8.48	348,465	93,911	1,307,372	2	$696,930	$187,822	17.1	17.0	$11,069
6	plant 15	1,865,855	11.6	1,647	9.30	0.99	0.8	11.5	0.116	0.0930	9.21	348,919	94,011	1,313,503	1	$348,919	$94,011	9.30	9.21	$10,210
7	26	4,000,000	51.3	3,390	24.6	0.95	0.48	48.7	2.57	1.23	23.4	393,226	126,406	2,815,873	2	$786,451	$252,812	49.2	46.7	$5,409
8	20	1,819,000	8.94	1,299	3.46	0.544	0.387	4.86	4.08	1.58	1.88	407,235	89,310	1,280,518	1	$407,235	$89,310	3.46	1.88	$47,457
9	16a,b	5,600,000	1,144	54,001	326	0.44	0.286	504	641	183	143	476,348	134,688	3,942,222	1	$476,348	$134,688	326	143	$943
10	37e,f,g,j,k	40,357,268	485	3,175	93.4	0.335	0.193	162	322	62.2	31.2	1,014,351	349,837	28,410,237	1	$1,014,351	$349,837	93.4	31.2	$11,224
11	38a	5,250,000	90.9	4,577	17.5	0.335	0.193	30.5	60.5	11.7	5.83	568,614	128,821	3,695,834	1	$568,614	$128,821	17.5	5.83	$22,096
12	42	3,513,600	143	10,759	26.1	0.323	0.182	46.2	96.8	17.6	8.48	371,014	121,305	2,473,463	1	$371,014	$121,305	26.1	8.48	$14,313
13	43	885,600	35.9	10,716	6.98	0.336	0.194	12.1	23.8	4.63	2.35	392,790	73,824	623,434	1	$392,790	$73,824	6.98	2.35	$31,358
14	44	695,665	34.1	12,957	8.70	0.402	0.255	13.7	20.4	5.20	3.50	335,108	67,813	489,726	1	$335,108	$67,813	8.70	3.50	$19,383
15	plant 21	45,607,268	576	3,336	111	0.335	0.193	193	383	73.9	37.2	1,088,588	380,099	32,106,071	1	$1,088,588	$380,099	111	37.2	$10,218
16	plant 22	5,094,865	213	11,051	41.7	0.338	0.196	72.0	141	27.6	14.1	427,067	135,468	3,586,623	1	$427,067	$135,468	41.7	14.1	$9,606
17	19+20+21	10,700,000	52.6	1,300	20.4	0.544	0.387	28.6	24.0	9.29	11.1	581,860	173,148	7,532,461	1	$581,860	$173,148	20.4	11.1	$15,628
18	29	5,625	0.349	16,392	0.279	0.99	0.8	0.345	0.0035	0.0028	0.276	N/A	42,729	3,960	1	N/A	$3,960	0.279	0.272	$14,557
19	30	1,028	0.192	49,338	0.154	0.99	0.8	0.190	0.0019	0.0015	0.152	N/A	41,785	724	1	N/A	$724	0.154	0.150	$4,819
20	31	2,056	0.385	49,513	0.308	0.99	0.8	0.381	0.0039	0.0031	0.305	N/A	42,177	1,447	1	N/A	$1,447	0.308	0.300	$4,820
21	7	11,600	1.23	28,033	0.209	0.31	0.17	0.381	0.849	0.144	0.0647	N/A	46,173	8,166	3	N/A	$24,498	0.627	0.553	$44,285
22	23	47,000	1.81	10,179	0.308	0.31	0.17	0.561	1.25	0.212	0.0956	N/A	53,472	33,087	3	N/A	$99,260	0.924	0.815	$121,730
															30	$9,776,503	$2,869,419		934.5	$3,071

(a) Regulatory alternative emissions are based on the assumption that a steam stripper or offsite disposal as a hazardous waste (treated by incineration) is used to control emissions.

(b) Streams at surveyed plants 15, 21, and 22 combined for control with one stream stripper at each facility; still separate steam strippers for each stream at modelled plants.

Combined streams 19, 20, and 21 at a modelled plant because of their relationship to each other at the surveyed plant.

Combined streams 13a, 14a, and 15a at a modelled plant because of their relationship at the surveyed plant.

(c) It is assumed that a facility will use the least expensive control cost. Hazardous waste disposal costs ($0.704/gal or $169.02/ton) were developed for the 9 smallest streams. Steam stripper control costs were developed for 21 streams.

(d) Emission reduction for streams 1 through 17 are based on the reduction achieved by the steam stripper. The emission reduction for streams 18 through 22 are based on 98 percent reduction associated with hazardous waste disposal.

STEAM STRIPPER COST ALGORITHM

5/2/97

PAI NESHAP FILE:\PROJECT\AGCHEMS\WW-IMP\HON_SSR2.XLS

Design Inputs:

Feed Rate (gpm):	5.5	Feed=(Gal)(60)/Hours
Gallons/yr Stripp	695,665	Gal
On-Stream Time (hr/yr)	2,121.6	Hours
HAP concentration	12,973	Conc=(Massyr)/(Gal)/(8.33)(10^6)
HAP mass (lb/hr)	35.4	Masshr=(Conc)/(10^6)(Feed)(8.3)(60)
HAP Mass (lb/yr)	75,177	Massyr
HAP Identity		
L/V (feed-to-steam ratio)	10.4	Ratio
Steam Pressure (psig)	100	Pst
Steam Temperature (K)	450	Tst
Steam Hv (BTU/lb):	900	HVs
Sat'd steam Temp (F):	328	Tsat
Theoretical stages	5	Stage
Hap Removal	depends on Fr	
Required Feed Temp (F):	170	Tfeed
Bottoms Temp (F):	210	Tbot
Wastewater Temp (F):	68	Tww
Overheads Temp (F):	170	Tov
Overhead Hvap (BTU/lb):	1800	Hvov
Overheads Flow (lb/hr):	32	Massov
Decant Temp (F):	77	Tdec
Cool Outlet (F):	150	Tout

Cost Indices:

	Chemical Eng. Magazine 2/95
425.5	- Fabricated Equip.
389.5	- Tanks
389.5	- Condensers
595.5	- Pumps
356.0	CE plant index July 1989
382.0	CE plant index June 1995
252.5	HON Tower #1 CEM 1st quarter 1979
	- Fabricated equip. cost index
252.5	HON Tower #2 Peters & Timmerhaus CEM 1st quarter 197
	- Fabricated equip. cost index
252.5	HON Tanks CEM 1st quarter 1979
252.5	HON Decanter CEM 1st quarter 1979
356	HON Preheater CEM 7/89
457.7	HON Pumps CEM 9/88
365.4	HON Condensers CEM 9/88

Design Calculations

Bottom Approach Temp(F):	73	Tbotapp=Tww+5
Wastewater Flow (lb/hr)	2,731	Massww=(Feed)(8.33)(60)
Duration of Stripp (hrs)	2,121.6	Hours

Sizing Calculations:

Column

Steam Density (lb/ft3)	0.24	Denst=[(Pst)/(14.7)(760) + 760]+(18)/(999xTst)
Flooding Abcissa	0.64	Floodab=(Ratio)x(Denst/62.4)^0.5
Flooding Ord (for 18 in. tray spacin	0.12	Floodord=10^[1.04635-0.64549(log(Floodab))-0.19925(log(Floodab))^2]
Velocity at Flood, ft/s	1.90	Vel=(Floodord)[(62.4-Denst)/Denst]^0.5
Percent of Flood, %	80	%Flood
Tower Diameter (@80%flood) (ft)	0.80	D=[Massww/3600/Vel/(%Flood/100)(4)/3.1459]^0.5
Tower Height	21.39	H=3*Stage+3*D+4
Weight of Column (lb):	1,440	W=82.11xDx(H+0.8116xD)

Costs:

Column Cost: HON #1 ($):	$39,315	Cost1=1A+1B+1C(0.85)(1.189+0.0577*D)(382.0/230.9)
--shell,skirts,nozzles	$29,457	1A=[exp((6.823+0.14178*ln(W)+0.02468*(ln(W))^2)]*3.1
--platforms	$1,530	1B=151.81*(D^0.63316)*(H^0.80161)
--trays	$4,795	1C=(Stage)(3)(278.38)*exp(0.1739*D)

Column Cost: HON #2 ($):	$58,440	Cost2=(2A+2B+2C+2D+2E+2F+2G)(382.0/225.9)
--shell	$13,477	2A=(133.36)(W^0.6347)
--manholes	$15,107	2B=(Stage)(3)(18)(55.95)
--nozzles	$1,223	2C=(26)(24.57+35.94*0.6252)
--trays	$3,796	2D=(Stage)(3)(214.54)*exp(0.2075*D)
--ladders	$276	2E=(H)(30)(0.43)
--platforms	$145	2F=(D)(425)(0.43)
--insulation	$535	2G=(3.1459)(D)(H)(10)
Column Cost: Average of Two	$48,877	Cost=(Cost1+Cost2)/2
	TRAY	
Tanks		
Feed Volume, ft3	13,378	Feedvol=(48)(Gal)(Hours/0.85)
Feed Tank ($)	$25,093	If Feedvol>21,000 gal then COSTtk=exp(11.362-0.6104*ln(Feedvol)-0.045355*ln(Feedvol)^2)(382.0/230.9)
		Feedvol <21,000 gal then COSTtk=exp(2.331+1.3673*ln(Feedvol)-0.063088*ln(Feedvol)^2)(382.0/230.9)
Decanter ($)	$3,584	COSTdec=[(Feed/Ratio*60*2)^0.5502]*216.8(382.0/225.9)
Pumps		
Feed pump hp (for two pumps)	0.526	HPf=(Feed)(122)(8.33)/60/0.64*(0.001341)/(0.7376)(2)
Feed Pumps ($):	$10,946	COSTfp=(HP)^0.4207 * (8740.7)(2)(382.0/347.8)
Bottoms pump hp	0.263	HPb=(HPf)/(2)
Bottoms Pump ($):	$5,473	COSTbp=(COSTfp)/(2)
Overheads pump hp	0.025	HPo=(Feed)/(Ratio)(122)(8.33)/60/0.64*(0.001341)/(0.7376)
Overhead Pump- Aqueous ($):	$4,096	COSTop=(HVp)^0.4207 * (8740.7)(2)(382.0/347.8)
Feed Preheater		
LMTD	16.83	LMTDpre=[(Tbot-Tfeed)-(Tbotapp-Tww)]/[ln((Tbot-Tfeed)/(Tbotapp-Tww))]
Area (ft2)	97.37	AREApre=(Massww)(Tfeed-Tww)/(170*LMTD)
Cost($):	$7,476	If Feed<0.48 then COSTpre=(4213.357*(0.48)^0.5 - 2882.31)(382.0/356.0)
		If Feed>0.48 then COSTpre=(4213.357*(Feed)^0.5 - 2882.31)(382.0/356.0)
Steam Condenser		
LMTD	13.78	LMTDcond=[(Tov-Tout)-(Tdec-68)]/[ln((Tov-Tout)/(Tdec-68))]
Area (ft2)	111.36	AREAcond=[(Massww)/(Ratio)(HVs)+(Massww)/(Ratio)*(Tfeed-Tdec)]/170/LMTDcond
Cost ($):	$3,656	If AREAcond<240 then COSTcond=(2228.8*exp(0.00411*AREAcond))(356.0/343.0)
		If AREAcond>240 then COSTcond=(5328*exp(0.0008762*AREAcond))(382.0/343.0)
Flame Arrestor ($):	$5,000	COSTarr
Equipment Cost:	$114,201	EC=COST+COSTdec+COSTtk+COSTfp+COSTbp+COSTop+COSTpre+COSTcond+COSTarr
Piping:	$34,260	Piping=(EC)(0.30)
Instrumentation (10%)	$14,846	Instr=(EC+Piping)(0.10)
Sales Tax (3%)+ Freight (5%)	$13,065	STF=(EC+Piping+Instr)(0.08)
Purchased Equipment Cost:	$176,373	PEC=EC+Piping+Instr+STF
Installation (Direct):	$97,005	Id=(PEC)(0.55)
Installation (Indirect):	$61,730	Ii=(PC)(0.35)
Total Capital Investment:	$335,108	TCI=PEC+Id+Ii

Annualized Costs

Direct Annual Costs

Utilities		
Steam:	$2,342	Steam=(Massww)/(Ratio)(Hours)/(2204.62)(9.26)
(9.26/Mg)		
Electricity:	$76	Elec=(HPf+HPb+Hpo)(0.7457)(Hours)(0.059)
Cooling Water:	$118	Water=(Massww)/(Ratio)(HVs)/(Tov-68)(0.00002399)(Hours)
Labor		
SS op hours, hr/week	40.8	Hourss=Hours/52
(if process operates 52 wk/yr and SS operates at least once per wk)		
Operating Labor:	$2,984	If Hourss>=8 then OL=(0.5)/(8)(Hours)(22.50)
		If Hourss<8 and >=4 then OL=(1)/(8)(Hours)(22.50)
		If Hourss<4 and >=1 then OL=(4)/(8)(Hours)(22.50)
		If Hourss<1 then OL=(Hours)(22.50)
Supervision and Admin:	$448	SL=(OL)(0.15)
Maintenance		
Labor:	$2,984	ML=OL
Materials:	$2,984	MM=ML
Total Direct Annual Costs:	$11,975	DIRTAC=Steam+Elec+Water+Hourss+OL+SL+ML+MM

Indirect Annual Costs

Overhead	$5,639	O=(OL+SL+ML+MM)(0.60)
Property Taxes	$3,351	PT=(TCI)(0.01)
Insurance	$3,351	INS=(TCI)(0.01)
Administrative Charges	$6,702	A=(TCI)(0.02)
CRF: (7%, 15 yrs)	$36,795	CR=(TCI)(CRF)
Total Indirect Annual Costs:	$55,838	INDTAC=O+PT+INS+A+CR
Total Annualized Cost:	$67,813	TAC=DIRTAC+INDTAC

HAZARDOUS WASTE DISPOSAL COSTS FOR WASTEWATER FOR EXISTING SOURCE REGULATORY ALTER
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\WW-IMPAX\HAZWASTE.WQ2

	Stream	Flow rate per stream, gal/yr	Load per stream, Mg/yr	ppmw	Disposal as hazardous waste, $/yr
1	29	5,625	0.349	16,392	$3,960
2	30	1,028	0.192	49,338	$724
3	31	2,056	0.385	49,513	$1,447
4	7	11,600	1.23	28,033	$8,166
5	23	47,000	1.81	10,179	$33,087

EXAMPLE: Stream 29
Hazardous waste disposal cost is $0.704/gal or $169.02/ton. Stream 29 has a flow rate of 5,625 gallons per year.
5,625 gal/yr x $0.704/gal = $3,960/yr

ATTACHMENT D

- Costs and Cost Effectiveness Table for the Equipment Leak Regulatory Alternative for Existing Sources
- Example Cost Calculations for Batch Equipment Leak Model

COSTS, EMISSIONS, AND COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR EQUIPMENT LEAKS
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\ELEAKS\EL_IMP.XLS

Regulatory Alternative	Baseline Emissions (Mg/yr)	Capital Costs ($)	Annual Costs ($)	ER From Baseline (Mg/yr)	ER From Baseline (%)	Cost Effectiveness ($/Mg)
MACT floor	3,407	0	0	0	0	0
Subpart H	3,407	$3,397,000	$1,650,000	3,022	88.7%	$546

Data:

Processes	Number of processes	TCI, $/process	TAC, $/yr/process	Emissions, Mg/yr/process Baseline	Emissions, Mg/yr/process After subpart H	Nationwide TCI, $	Nationwide TAC, $/yr	Nationwide emissions, Mg/yr Baseline	Nationwide emissions, Mg/yr After subpart H	Cost effectiveness, $/Mg
Batch EL model	138	$15,401	$9,977	11.34	1.14	$2,125,338	$1,376,826	1,565	157	978
Continuous EL model	37	$25,341	$928	46.34	5.02	$937,617	$34,336	1,715	186	22
Process 1	1	$11,910	$1,582	1.43	0.093	$11,910	$1,582	1.43	0.093	1,183
Process 4	1	$9,371	$3,176	0.560	0.044	$9,371	$3,176	0.560	0.044	6,155
Process 20	1	$83,112	$24,816	10.7	1.10	$83,112	$24,816	10.7	1.10	2,585
Process 23	1	$24,517	$20,599	29.2	4.79	$24,517	$20,599	29.2	4.79	844
Process 24	1	$24,517	$49,086	1.95	0.319	$24,517	$49,086	1.95	0.319	30,096
Process 25	1	$24,517	$46,755	4.17	0.684	$24,517	$46,755	4.17	0.684	13,412
Process 26	1	$24,517	$46,755	4.17	0.684	$24,517	$46,755	4.17	0.684	13,412
Process 10	1	$12,800	$6,685	2.64	0.239	$12,800	$6,685	2.64	0.239	2,784
Process 22	1	$37,335	$19,531	2.02	0.164	$37,335	$19,531	2.02	0.164	10,523
Process 14	1	$19,387	$11,926	1.27	0.106	$19,387	$11,926	1.27	0.106	10,246
Process 11	1	$14,606	($15,883)	24.1	2.07	$14,606	($15,883)	24.1	2.07	(722)
Process 13	1	$17,785	$6,928	7.06	0.625	$17,785	$6,928	7.06	0.625	1,077
Process 6	1	$10,376	$3,739	3.08	0.282	$10,376	$3,739	3.08	0.282	1,336
Process 9	1	$18,894	$13,339	3.79	0.368	$18,894	$13,339	3.79	0.368	3,898
Implementing subpart H	14	$0	$0	2.26	2.26	$0	$0	31.6	31.6	0
	203					$3,396,599	$1,650,196	3,407	386	546

EXAMPLE COST CALCULATIONS FOR THE BATCH MODEL

I. CAPITAL COSTS

1. Equipment costs

compressor	0 x $6,633 =	$0
open-ended lines	0 x $108 =	$0
sample connections	0 x $434 =	$0
pressure relief devices	0 x $4,176 =	$0
monitoring instrument	1 x $6,907 =	$6,907

		$6,907

2. Initial monitoring cost (Not part of the Capital Cost, but is annualized under section II. Annual Costs.)

Component	No. components	Monitoring Cost (# comp. x $2.50)	Initial monitoring cost (Cost x 1.4)
Gas valves	65	162.50	227.50
Liquid valves	340	850.00	1,190.00
Pump	14		
pump		35.00	49.00
replacement seals		N/A	N/A
Flanges	1,100	2,750	3,850

3. Initial repair cost (Not part of the Capital Cost, but is annualized under section II. Annual Costs.)

Component	No. components	Initial leak frequency	Fraction require repair	Hour per repair	Repair cost (x $22.50)[a]	Initial repair cost (Cost x 1.4)
Gas valves	65	0.114	0.25	4	166.72	233.41
Liquid valves	340	0.065	0.25	4	497.25	696.15
Pump	14					
pump		0.20	0.75	16	756.00	1,058.4
replacement seals[b]		0.20	0.75	N/A	N/A	401.73
Flanges	1,100	0.021	0.25	2	259.87	363.82

[a]Not applicable to pump replacement seals.
[b]Initial repair cost for replacement seals is equal to the number of components, times the leak frequency, times the fraction requiring repair times a cost of $191.30 per replacement seal. No administrative charges are included for this repair cost.

II. ANNUAL COSTS

1. Indirect annual costs

a. Annualized equipment costs

compressor	0 x $6,633 x 0.14 =	$0
open-ended lines	0 x $108 x 0.14 =	$0
sample connections	0 x $434 x 0.14 =	$0
pressure relief devices	0 x $4,176 x 0.14 =	$0
monitoring instrument	1 x $6,907 x 0.21 =	$1,450

		$1,450

b. Annualized initial monitoring

Component	Initial monitoring cost	CRF	Annualized initial monitoring cost (Cost x CFR)
Gas valves	227.50	0.14	31.85
Liquid valves	1,190	0.14	166.66
Pump			
pump	49.00	0.14	6.86
replacement seals	N/A	0.55	N/A
Flanges	3,850	0.14	539.00
TOTAL			744.37

c. Annualized initial repair costs

Component	Initial repair cost	CRF	Annualized initial repair cost (Cost x CFR)
Gas valves	233.41	0.14	18.63
Liquid valves	696.15	0.14	170.93
Pump			
pump	1,058.40	0.14	148.12
replacement seals	401.73	0.55	220.95
Flanges	363.82	0.14	50.93
TOTAL			609.62

2. Direct annual costs

a. Annual maintenance charges

monitoring instrument	1 x $4,548 =	$0
compressor	0.05 x $0 =	$0
pressure relief devices	0.05 x $0 =	$0
open-ended lines	0.05 x $0 =	$0
sampling connections	0.05 x $0 =	$0
pump replacement seals	12.6 x $191 =	$2,406.60

		$2,406.60

b. Annual miscellaneous charges

monitoring instrument	0.04 x $6,907 =	$276
compressor	0.04 x $0 =	$0
pressure relief devices	0.04 x $0 =	$0
open-ended lines	0.04 x $0 =	$0
sampling connections	0.04 x $0 =	$0
pump replacement seals	0.80 x $401.10 =	$1,925.28

		$2,201.28

c. Annual labor charges

Annual monitoring labor

Component	No. components	No. of monitorings per year	Cost (# comp. x $2.00)[a]	Annual monitoring cost (Cost x 1.4)
Gas valves	65	4	520	728.00
Liquid valves	340	4	2,720.00	3,808.00
Pump	14			
pump		12	336.00	470.40
visual monitoring[b]		52	136.50	191.10
Flanges	1,100	1	2,200	3,080.00
Pressure relief device	0	1	0	0
TOTAL				8,277.50

[a]Not applicable to visual monitoring of pumps.
[b]Annual monitoring cost for visually monitoring pumps is equal to the number of pumps, times 52 monitorings per year, times 30 seconds per pump, divided by 3,600 seconds per hour, times a labor cost of $22.50 per hour.

Annual repair labor

Component	No. components	No. of leak frequency	No. of monitorings per year	Fraction require repair	Hour per repair	Cost (x $22.50)	Annual repair cost (Cost x 1.4)
Gas valves	65	0.02	4	0.25	4	117.00	81.90
Liquid valves	340	0.02	4	0.25	4	612.00	428.40
Pump	14						
pump		0.10	12	0.75	16	4,536.00	6,350.40
Flanges	1,100	0.05	1	0.25	2	6189.75	173.25
TOTAL							7,033.95

Annual labor charges = monitoring labor + repair labor
= $8,277.50 + 7,033.95
= $15,311.45

3. Product recovery credit

emission reduction = 10.20 Mg (Estimated in the Environmental Impacts memo)
recovery credit = $1,250/Mg

10.20 Mg x $1,250/Mg = $12,750 credit

4. Calculation of total annual cost

	annualized equipment	1,450.47
	annualized initial monitoring	744.37
	annualized initial repair	609.62
	annual maintenance charges	2,406.60
	annual miscellaneous charges	2,201.28
+	annual labor charges	15,311.45
-	product recovery credit	12,750.00
	TOTAL ANNUAL COST	9,973.79

ATTACHMENT E

- Costs and Cost Effectiveness Table for the Process Vent MACT Floor for New Sources

NEW SOURCE MACT FLOOR COSTS FOR PROCESS VENTS
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\DATADDR\PV-NEWCE.XLS

Plant	HAP content	Total	Control device	TCI per model, $	Nationwide TCI, $/yr	TAC per model, $/yr	Nationwide TAC, $/yr	Uncontrolled emissions, Mg/yr organics	Uncontrolled emissions, Mg/yr HCl	Created HCl, Mg/yr	Uncontrolled HAP emissions per process, Mg/yr	Baseline HAP emissions per process, Mg/yr	HAP emissions at floor per process, Mg/yr	Incremental emission reduction per process, Mg/yr	Nationwide uncontrolled HAP emissions, Mg/yr	Nationwide baseline HAP emissions, Mg/yr	Nationwide incremental emission reduction, Mg/yr	Overall cost effectiveness, $/Mg
A1	1d	1	incinerator	431,000	431,000	218,000	218,000	13.7	0	0	13.7	2.7	0.3	2.5	13.7	2.7	2.5	88,400
A2	1c98	1	condenser	356,000	356,000	138,000	138,000	13.7	0	0	13.7	2.7	0.3	2.5	13.7	2.7	2.5	56,000
A3	1c98	1	condenser	356,000	356,000	138,000	138,000	13.7	0	0	13.7	2.7	0.3	2.5	13.7	2.7	2.5	56,000
B1	2d	1	incinerator	401,000	401,000	188,000	188,000	40	66.1	17.9	124.0	8.8	1.6	7.2	124.0	8.8	7.2	26,100
B2	2c98	1	condenser	159,000	159,000	88,100	88,100	40	66.1	0	106.1	8.7	1.5	7.2	106.1	8.7	7.2	12,200
C1	1d	1	incinerator	431,000	431,000	218,000	218,000	13.7	0	0	13.7	2.7	0.3	2.5	13.7	2.7	2.5	88,400
	3d	1	incinerator	972,000	972,000	831,000	831,000	41	0	0	41.0	8.2	0.8	7.4	41.0	8.2	7.4	112,600
C2	1c98	1	condenser	356,000	356,000	138,000	138,000	13.7	0	0	13.7	2.7	0.3	2.5	13.7	2.7	2.5	56,000
	3c98	1	condenser	181,000	181,000	67,900	67,900	41	0	0	41.0	8.2	0.8	7.4	41.0	8.2	7.4	9,200
D2	1d	1	incinerator	431,000	431,000	218,000	218,000	13.7	0	0	13.7	2.7	0.3	2.5	13.7	2.7	2.5	88,400
	2dH	2	incinerator/scrubber	475,000	950,000	265,000	530,000	40	66.1	17.9	124.0	24.8	1.6	23.2	248.0	49.6	46.3	11,400
	4dH	2	incinerator/scrubber	1,446,000	2,892,000	942,000	1,884,000	102	295	67.8	464.8	93.0	5.7	87.3	929.6	185.9	174.6	10,800
		14			7,916,000		4,657,000								1,572	286	265	17,583

ATTACHMENT F

- Costs and Cost Effectiveness Table for the Storage Tank MACT Floor for New Sources

NEW SOURCE MACT FLOOR COSTS FOR STORAGE TANKS
PAI NESHAP FILE: F:\PROJECT\AGCHEMS\TANKS\STNEWCST.XLS

Plant	Model tank	No. models	TCI per model, $	Nationwide TCI, $/yr	TAC per model, $/yr	Nationwide TAC, $/yr	Uncontrolled HAP emissions Mg/yr	Baseline HAP emissions Mg/yr	HAP emissions at floor Mg/yr	Incremental emission reduction Mg/yr	Nationwide uncontrolled HAP emissions, Mg/yr	Nationwide baseline HAP emissions, Mg/yr	Nationwide incremental emission reduction, Mg/yr	Overall cost effectiveness, $/Mg
A1	1B	1	52,060	52,060	71,938	71,938	0.267	0.237	0.157	0.080	0.267	0.237	0.080	899,400
A2	1B	1	52,060	52,060	71,938	71,938	0.267	0.237	0.157	0.080	0.267	0.237	0.080	899,400
A3	1B	1	52,060	52,060	71,938	71,938	0.267	0.237	0.157	0.080	0.267	0.237	0.080	899,400
B1	None	None												
B2	None	None												
C1	3B	1	219,548	219,548	102,551	102,551	0.876	0.824	0.517	0.307	0.876	0.824	0.307	334,400
C2	3B	1	219,548	219,548	102,551	102,551	0.876	0.824	0.517	0.307	0.876	0.824	0.307	334,400
D2	2B	1	58,684	58,684	73,147	73,147	0.549	0.549	0.324	0.225	0.549	0.549	0.225	324,800
		6		653,960		494,063					3.10	2.91	1.08	458,105

ATTACHMENT G

- Costs and Cost Effectiveness Table for the Wastewater Regulatory Alternative 2 for New Sources

REGULATORY ALTERNATIVE 2 COSTS, EMISSION REDUCTIONS, AND COST EFFECTIVENESS FOR NEW SOURCES

5/7/97

PAI NESHAP FILE: F:\PROJECT\AGCHEMS\WW_IMPAX\SSNEWCST.XLS

	Stream	Flow (gpy)	Process hr/yr	Flow during process gpm	Needed SS size (85% on) gpm	Actual SS size gpm	SS op. hr/yr	Load (lb/yr)	ppmw	RA1 TCI ($)	RA1 TAC ($)	RA1 Em. Red Mg/yr/process	Disposal as hazardous waste, $/yr	RA2 Unc. Em. Mg/yr	Fr	RA2 Removed from load, Mg/yr	RA2 Left in water, Mg/yr	Fe
1	9	13,500,000	5,300	42.5	49.9	49.9	4,505	2,000	17.8	$ -	$ -	0	9,504,000	0.834	0.99	0.898	0.009	0.92
2	11	2,630,000	7,680	5.71	6.71	6.71	6,528	399	18.2	$ -	$ -	0	1,851,520	0.169	0.99	0.179	0.002	0.93
3	22a,b,c,d	403,600	1,368	4.92	5.78	5.78	1,163	1,752	520.6	$ -	$ -	0	284,134	0.636	0.99	0.787	0.008	0.8
4	28	1,824	960	0.032	0.037	5.00	6.08	112	7,362	$ -	$ -	0	1,284	0.041	0.99	0.0503	0.001	0.8
5	37i	40,367,768	8,400	80.1	94.2	94.2	7,140	1,069,210	3,176	$ 1,014,351	$ 349,837	31.2	28,418,909	93.4	0.33	162	323	0.1926
6	38b,c	5,426,050	4,056	22.3	26.2	26.2	3,448	201,189	4,446	$ 568,614	$ 128,821	5.83	3,819,939	17.7	0.34	30.7	60.6	0.1943
7	39	222,071	1,036	3.57	4.20	5.00	740	70.1	37.9	$ -	$ -	0	156,338	0.025	0.99	0.031	0.000	0.8
8	40	777,600	456	28.4	33.4	33.4	388	1,451	224	$ -	$ -	0	547,430	0.526	0.99	0.652	0.007	0.8
9	41	705,600	300	39.2	46.1	46.1	255	1,382	235	$ -	$ -	0	496,742	0.502	0.99	0.621	0.006	0.8
10	45	933,120	1,542	10.1	11.9	11.9	1,311	871	112	$ -	$ -	0	656,916	0.316	0.99	0.391	0.004	0.8

(a) The incremantal TAC and the incremental emission reduction from regulatory alternative 1 to 2 is based on steam strippers for all streams but stream 28. The incremental annual cost and emission reduction for stream 28 are based on hazardous waste dispoal costs and 98 percent emission reduction.

RA2 Controlled emissions after SS, Mg/yr	RA2 Em Reduc. from Unc Mg/yr/process	RA2 TCI ($)	RA2 TAC ($)	RA1 to RA2 Incremental TCI ($)	RA1 to RA2 Incremental TAC ($)	RA1 to RA2 Incremental Em Red Mg/yr/process	RA1 to RA2 Incremental CE ($/Mg)	Number of streams to control nationwide	Nationwide RA1 to RA2 Incremental TCI ($)	Nationwide RA1 to RA2 Incremental TAC ($) (a)	Nationwide RA1 to RA2 incremental reduction, Mg/yr (a)	RA1 to RA2 Incremental C/E ($/Mg)	Nationwide flowrate gal/yr
0.008	0.826	$ 746,372	$ 193,044	$ 746,372	$ 193,044	0.826	$233,683	3	$ 2,239,116	$ 579,132	2.48	$233,683	40,500,000
0.002	0.167	$ 354,787	$ 109,129	$ 354,787	$ 109,129	0.167	$653,443	2	$ 709,574	$ 218,258	0.334	$653,443	5,260,000
0.006	0.630	$ 340,393	$ 60,726	$ 340,393	$ 60,726	0.63	$96,466	2	$ 680,786	$ 121,452	1.26	$96,466	807,200
0.0004	0.040	$ 261,175	$ 39,820	$ 261,175	$ 39,820	0.040	$989,764	2	N/A	$ 2,568	0.0996	$25,794	3,648
62.2	31.2	$ 1,014,498	$ 349,897	$ 147	$ 60	0.018	$3,288	2	$ 294	$ 120	0.0365	$3,288	80,735,536
11.8	5.96	$ 575,699	$ 130,525	$ 7,085	$ 1,704	0.128	$13,313	2	$ 14,170	$ 3,408	0.256	$13,313	10,852,100
0.000	0.0252	$ 324,702	$ 54,711	$ 324,702	$ 54,711	0.025	$2,172,223	2	$ 649,404	$ 109,422	0.0504	$2,172,223	444,142
0.005	0.521	$ 632,224	$ 103,044	$ 632,224	$ 103,044	0.521	$197,730	2	$ 1,264,448	$ 206,088	1.04	$197,730	1,555,200
0.005	0.497	$ 721,254	$ 114,236	$ 721,254	$ 114,236	0.497	$230,044	2	$ 1,442,508	$ 228,472	0.993	$230,044	1,411,200
0.003	0.313	$ 436,313	$ 78,077	$ 436,313	$ 78,077	0.313	$249,577	2	$ 872,626	$ 156,154	0.626	$249,577	1,866,240
								21	$ 7,872,926	$ 1,625,074	7.17	$ 226,497	143,435,266

ATTACHMENT H

- Costs and Cost Effectiveness Table for the Equipment Leak MACT Floor for New Sources

COSTS OF NEW SOURCE MACT FLOOR FOR EQUIPMENT LEAKS

PAI NESHAP FILE: F:\PROJECT\AGCHEMS\ELEAKS\ELNEWCST.XLS

Plant	Processes	Number of processes	TCI, $/process	CR, $/yr/process	TAC, $/yr/process	Emissions, Mg/yr/process Baseline	Emissions, Mg/yr/process After subpart H	Nationwide TCI, $	Nationwide TAC, $/yr	Nationwide emissions, Mg/yr Baseline	Nationwide emissions, Mg/yr After subpart H	Cost effectiveness, $/Mg
A1	Batch EL model	1	$15,401	2804	$9,977	11.34	1.14	$15,401	$9,977	11.3	1.14	978
A2	Batch EL model	1	$15,401	4419	$9,977	11.34	1.14	$15,401	$9,977	46.3	5.02	241
A3	Batch EL model	1	$15,401	2151	$9,977	11.34	1.14	$15,401	$9,977	11.3	1.14	978
B1	Batch EL model	2	$15,401	1807	$9,977	11.34	1.14	$30,802	$19,954	22.7	2.27	978
B2	Batch EL model	2	$15,401	12849	$9,977	11.34	1.14	$30,802	$19,954	22.7	2.27	978
C1	Batch EL model	2	$15,401	4304	$9,977	11.34	1.14	$30,802	$19,954	22.7	2.27	978
	Continuous EL model	1	$25,341	4304	$928	46.34	5.02	$25,341	$928	46.3	5.02	22
C2	Batch EL model	2	$15,401	4304	$9,977	11.34	1.14	$30,802	$19,954	22.7	2.27	978
	Continuous EL model	1	$25,341	4304	$928	46.34	5.02	$25,341	$928	46.3	5.02	22
D2	Batch EL model	3	$15,401	2299	$9,977	11.34	1.14	$46,203	$29,931	34.0	3.41	978
	Continuous EL model	2	$25,341	5793	$928	46.34	5.02	$50,682	$1,856	92.7	10.0	22
		18						$316,978	$143,390	379	39.9	423